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AIR TRAFFIC ORGANIZATION

ATO Technology Development

Performance Metrics Results to Date
October 2004

This is the fourth semi-annual report on Air Traffic Organization (ATO) Technology Development (formerly Safe Flight 21 and Surface Technology Assessment) performance metrics. The intent is to describe performance metrics analyses and results performed from May 2004 through October 2004. This edition contains summaries of previous work and presents many new analyses. The new studies include:

An examination of flight time/distance for Automatic Dependent Surveillance-Broadcast (ADS-B) equipped United Parcel Service, Inc. (UPS) aircraft at Louisville International Airport (SDF),

An updated chart of ADS-B usage along the East Coast corridor,

An updated assessment of taxi times and queue lengths at Dallas/Fort Worth International Airport (DFW) after implementation of an Airport Surface Detection Equipment Model X (ASDE-X) feed in the Delta Air Lines ramp tower,

An updated study of taxi times, queue lengths, and departure rates at Memphis International Airport (MEM) after implementation of a prototype Surface Management System (SMS) in the Federal Express ramp tower and operation center,

A description of how surface surveillance from the Airport Target Identification System (ATIDS) allowed Northwest Airlines to make long-term changes to their deicing procedures at Detroit Wayne County Metropolitan Airport (DTW),

A description of the ongoing evaluation of Runway Guard Lighting (RGL) at North Las Vegas Airport (VGT).

EXECUTIVE SUMMARY

This is the fourth semi-annual report on Air Traffic Organization (ATO) Technology Development (formerly Safe Flight 21 and Surface Technology Assessment) performance metrics. It presents performance metrics analyses and results performed from May 2004 through October 2004.

There are numerous performance metrics activities within ATO Technology Development that include research analysts from the following organizations: the FAA, American Airlines, Calibre Systems, Inc., The CNA Corp. (CNAC), Dallas/Fort Worth International Airport, Delta Air Lines, Federal Express (FedEx), Global Engineering Management Services, Inc. (GEMS), Johns Hopkins Applied Physics Lab, MCR Federal, MITRE CAASD, Northwest Airlines, Sensis Corp., Trios Associates, Inc., United Parcel Service Inc. (UPS), Veracity Engineering, and the Volpe National Transportation Systems Center. The purpose of the combined metrics effort is to consolidate the ongoing metrics activities and perform new analyses where needed. This report compiles the various efforts performed during the last six months into one document for ease of use. Results from these analyses will be incorporated as part of future program cost-benefit and investment analyses.

This document is divided into separate sub-sections for each site where there is an active metrics effort.

SDF: Safe Flight 21(SF-21) continues to develop a test-bed for early implementation of NAS equipment at Louisville International Airport (SDF). Currently, SF-21 is exploring the benefits of using Automatic Dependent Surveillance-Broadcast (ADS-B) equipment and procedures in the terminal area, and shared multilateration surveillance data on the surface. An ADS-B environment allows equipped aircraft to see surrounding aircraft on a Cockpit Display of Traffic Information (CDTI). Surface multilateration allows real-time surveillance for use by airline ramp control and management. We began a metrics working group at SDF in August 2003 that includes members from United Parcel Service (UPS), the Jefferson County Regional Airport Authority, and local ATC. In this document, we summarize previous analyses from *Performance Metrics Results to Date April 2004* [1], and present a new analysis on flight distances and times for UPS arrivals at SDF.

The new analysis examines distances and times for all UPS arrivals at SDF, UPS arrivals during a high equipage peak, and non-UPS arrival as a control group. We compare track data from the first nine months of full CDTI equipage to two nine-month baseline sets. The first baseline set excludes data during the equipage ramp-up period; the second set includes some of this transition period data. We divided data into different weather conditions (Visual Approach, VA, conditions and Instrument Approach, IA, conditions) and airport configurations (North Flow and South Flow). Flight distance/time results using both baseline sets were similar. We list the results for the baseline set that excluded transition period data in the following table. Positive values signify decreases in flight distance or time in the post-implementation period. A decrease in time or distance represents an increase in efficiency. **Not Sig** identifies a difference in means that was not statistically significant at the 95% level. UPS flights showed significant distance savings during North Flow operations. The savings tend to be even larger for aircraft that arrive during the high CDTI equipage peak.

Using Baseline Data Set 1	Metric	Non-UPS flights	All UPS flights	B757/767 peak UPS flights
VA North	**Dist Savings**	0.3 nmi	1.5 nmi	2.9 nmi
	Time Savings	17 sec	16 sec	40 sec
	% flights in config	31%	51%	61%
IA North	**Dist Savings**	Not Sig	3.9 nmi	5.6 nmi
	Time Savings	Not Sig	57 sec	76 sec
	% flights in config	8%	11%	11%
VA South	**Dist Savings**	0.5 nmi	1.3 nmi	Not Sig
	Time Savings	25 sec	21 sec	Not Sig
	% flights in config	52%	32%	24%
IA South	**Dist Savings**	Not Sig	Not Sig	Not Sig
	Time Savings	Not Sig	Not Sig	Not Sig
	% flights in config	9%	6%	4%

East Coast and Embry-Riddle Aeronautical University (ERAU): The SF-21 Flight Safety Application Group has been instrumental in stimulating production and self-equipage of ADS-B for the general aviation (GA) community. They have begun to provide free traffic and weather information from several ADS-B ground stations along the East Coast. They also support ADS-B implementation at ERAU at Prescott, Arizona and Daytona Beach, Florida. Both ERAU sites became operational in the summer of 2004. In this document we examine current total ADS-B equipage (GA and carrier) as detected from available ground stations.

Gulf of Mexico (GOM): In March of 2003, the En route and Oceanic Group began a concerted effort to identify benefits for ADS-B, improved communications, and automated weather observations in the Gulf of Mexico. The metrics team assisted in the benefits identification process, and was active in gathering and analyzing baseline data for this effort. In *Performance Metrics Results to Date April 2004* [1], we presented the current benefits analyses.

DFW: As part of the Runway Incursion Reduction Program (RIRP), the FAA began installation of an Airport Surface Detection Equipment - Model X (ASDE-X) multilateration system at the Dallas-Fort Worth International Airport (DFW). NASA and the DFW Airport Board have continued installation. In March 2002, the FAA agreed to provide real-time multilateration surface data to American Airlines, Delta Air Lines, and the DFW Airport Board. The shared surface surveillance feed became stable enough for consistent use in November 2003. The metrics team began a metrics working group in December 2003. In this document we summarize previous analyses from *Performance Metrics Results to Date April 2004* [1], update an assessment of taxi times and queue lengths after ASDE-X feed implementation in the Delta Air Lines ramp tower, and describe some near-future applications of surface surveillance for American Airlines.

Our taxi time analysis at DFW compares taxi-out times for Delta Air Lines aircraft to all the other aircraft at the airport. The baseline and post-implementation periods each contain ten months of archived taxi data. We divided data into different weather conditions (Visual Approach, VA, conditions and Instrument Approach, IA, conditions) and airport configurations (North Flow and South Flow). While the average taxi-out time for all airlines has increased at DFW due to increased traffic levels (7 percent increase in the past year), the increase in taxi-out time for Delta flights has not been as large as for the other flights at DFW. The following table presents the taxi-out change. Positive values represent increases in taxi-out time. **Not sig** identifies a difference in means that was not statistically significant at the 95% level**.**

	Taxi-out Change (min)			
	North Flow, VA	**South Flow, VA**	**North Flow, IA**	**South Flow, IA**
Delta	**+0.3**	**+0.8**	**-3.1**	**-0.1 (Not sig)**
DFW (non-Delta)	**+1.3**	**+1.6**	**-1.2**	**+2.2**

MEM: The SF-21 Surface Applications group assisted Federal Express (FedEx) and Northwest Airlines (NWA) in obtaining data for surface surveillance systems for use by ramp controllers and others within these airlines to whom this information is useful. The shared data is part of the prototype Surface Management System (SMS). In *Performance Metrics Results to Date April 2004* [1], we used an unexpected loss of surveillance to gauge the operational impact of surface data to FedEx. In this document, we present a quick summary of those results and update the taxi-out analysis to examine queue lengths and departure rates. Using two different sets of data we find an increase in the departure rate of approximately **3 aircraft/hour**.

DTW: The FAA assisted Northwest Airlines (NWA) in obtaining surface surveillance data from a prototype multilateration system, the Airport Target Identification System (ATIDS) at Detroit Wayne County Metropolitan Airport (DTW). NWA uses this data on a daily basis as the primary display for each controller in the ramp control tower, and has several displays for analysts, managers, and dispatchers at the Systems Operations Center (SOC) in Minneapolis. In *Performance Metrics Results to Date October 2003* [2], we described the benefit mechanisms and presented estimations of the benefits in detail. In this document, we provide a quick summary of previous results and present a new description of how ATIDS helped NWA permanently transform deicing operations. The new description includes a list of long-term changes.

North Las Vegas (VGT): The Surface Technology Assessment Product Team of ATO Technology Development is testing the effectiveness of enhanced additional Runway Guard Lighting (RGL) as a runway incursion prevention tool to be used uniformly on the airport surface during all weather conditions. These lights assist pilots in identifying the runway hold position usually identified by surface markings or runway hold signs. In this document we describe the current metrics activities at VGT.

If you have questions or comments on this document or the Safe Flight 21 and Surface Technology Assessment metrics program please contact Steve Ritchey at 202-267-5153 or Dan Howell at 202-624-3238.

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1.0 INTRODUCTION

This is the fourth semi-annual report on ATO Technology Development (formerly Safe Flight 21 and Surface Technology Assessment) performance metrics. The intent is to describe performance metrics analyses and results performed from April 2004 through October 2004.

The metrics effort consolidates ongoing metrics activities and performs new analyses where needed. The goal of this effort is to provide information for management oversight and communication with stakeholders by gauging the current operational impact and user benefits of Safe Flight 21 and Surface Technology Assessment initiatives.

There are numerous performance metrics activities within the organization that include research analysts from the following organizations: the FAA, American Airlines, Calibre Systems, Inc., The CNA Corp. (CNAC), Dallas/Fort Worth International Airport, Delta Air Lines, Federal Express (FedEx), Global Engineering Management Services, Inc. (GEMS), Johns Hopkins Applied Physics Lab, MCR Federal, MITRE CAASD, Northwest Airlines, Sensis Corp., Trios Associates, Inc., United Parcel Service Inc. (UPS), Veracity Engineering, and the Volpe National Transportation Systems Center. This report compiles the various efforts performed during the last six months into one document for ease of use. Results from these analyses will be incorporated as part of future program cost-benefit and investment analyses.

Performance metrics are quantitative measures of operational impacts. They are measures of changes in activity, including but not limited to: runway incursion rates, actual arrival and departure rates, flying time and distance for flight segments, and taxi times. The benefit of these activity changes may only apply during specific demand loads or during certain weather conditions. We will adjust the metrics as needed to best reflect the capabilities of the applications and initiatives.

The metrics reflect the FAA's operational goals and the expected program operational impacts. As we gain more experience with the program capabilities, the performance metrics will evolve. The metrics will remain flexible, and they will be refined as a direct result of feedback from FAA staff and users. We expect to incorporate additional metrics into future documents, especially after the implementation of new tools or initiatives.

Note that performance metrics can differ from programmatic metrics. Programmatic metrics assess whether a program or tool attains its intended function: the cost, maturity, risk, and functionality of the capability itself. An example of a programmatic metric might be the effective range of an ADS-B transmitter. These programmatic metrics are important for the operational impact evaluation, as they demonstrate the cause of an observed change in NAS performance. The metrics team will work closely with the individual Safe Flight 21 and Surface Technology Assessment Product Teams to associate tool performance with operational impacts.

Cost/benefit analyses attempt to translate the impacts of applications into economic benefits. These analyses are necessary for continued use and increased implementation of such applications. The cost/benefit team concentrates on estimating future benefits for sites before implementation. The metrics effort focuses on current benefits, but will use estimates from prior cost/benefit analyses and, in turn, provide refined estimates for use in future benefits studies.

1.1 Relation to other documents

The first step in the metrics process was to consolidate the separate metrics efforts into a combined effort. Much of the metrics/benefits work involves the Safe Flight 21 (SF-21) team. Consequently, this report borrows heavily from the Safe Flight 21 Master Plan Version 3 [3] and a previous cost/benefit analysis from the SF-21 Cost/Benefit Analysis group [4].

The Safe Flight 21 Master Plan [3] outlines nine major enhancements. These are:

Weather and Other Information In The Cockpit

Cost-Effective Controlled-Flight-Into-Terrain (CFIT) Avoidance

Improved Terminal Operations in Low Visibility

Enhanced See and Avoid

Enhanced En Route Air-to-Air Operations

Improved Surface Surveillance and Navigation for the Pilot

Enhanced Surface Surveillance for the Controller

ADS-B Surveillance in Non-Radar Airspace

ADS-B Surveillance in Radar Airspace

The nine enhancements involve several applications grouped into four classifications for effective management: Surface Applications, Terminal Applications, En route and Oceanic Applications, and Flight Safety Applications. In this report, we will establish a link to the nine enhancements where appropriate. We will also measure the impact of additional enhancements beyond the initial nine listed in the Master Plan.

It is hoped the enhancements provided by the SF-21 applications will positively impact the system by producing safety and efficiency user benefits. Prior cost/benefit work describes such potential benefits and estimates the effectiveness of these applications.

Table 1-1 from The Safe Flight 21 Pre-Investment Analysis Cost/Benefit Analysis (CBA) Phase II Report [4] lists both safety and efficiency benefits for which economic benefits were estimated. Note that some of the impacts rely on the interdependency of more than one enhancement.

Table 1-1. Safety and Efficiency Benefits Quantified

Safety Benefits	Efficiency Benefits
Enh1: Weather Accident Reduction Benefits	Enh1: More Efficient Routes in Adverse Weather*
Enh1: NOTAMs Related Accident Reduction Benefits*	Enh3: Reduction in MVMC Arrival Delays*
Enh2: CFIT Accident Reduction Benefits	Enh6: Reduction in Taxi Times Due to Pilots Enhanced Situational Awareness
Enh4: Mid-Air Collision Accident Reduction Benefits	Enh8: Reduction in SVFR Delays*
Enh8: More Timely Search and Rescue Benefits*	Enh8: More Efficient Search and Rescue Benefits*
Enh6&7: Surface Accident Reduction Benefits	Enh3&7: Reduction in Arrival and Departure Delays

* Benefits not previously quantified in the Phase I analysis

The Phase II CBA report provides comprehensive lists of benefits for each enhancement beyond those quantified in Table 1-1. The benefits include qualitative and quantitative measures for both safety and efficiency.

In this report, we define appropriate metrics to demonstrate the benefits, choosing to focus on benefits that can be measured with available resources. As mentioned in the previous section, we will organize the metrics by application group. However, we will refer back to the nine enhancements when possible in order to aid future benefits analyses. The CBA group will extrapolate the results of these metrics to support continued use and wider implementation of the SF-21 applications.

1.2 Organization

The remainder of this document is divided into separate sections for each Safe Flight 21 and Surface Technology Assessment site where there is an active metrics effort.

Section 2 – Louisville International Airport, Standiford Field (SDF)

Section 3 - East Coast and Embry-Riddle Aeronautical University (ERAU)

Section 4 – Gulf of Mexico (GOM)

Section 5 – Dallas Fort Worth International Airport (DFW)

Section 6 – Memphis International Airport (MEM)

Section 7 – Detroit Wayne County Metropolitan Airport (DTW)

Section 8 – North Las Vegas Airport (VGT)

Each section contains subsections that review the system description and history at that site, explain the metrics activities, and present results.

1.3 What is a benefits flow?

In the introduction, we defined performance metrics as measures of changes in activity. While measuring a change in a particular metric is simple, interpreting the results is sometimes difficult. The most complex part of benefits analysis is attributing a change to the use of an application. We attempt to better understand the activity changes by outlining the mechanisms for benefit in a specific format, which we call a “benefits flow.”

The benefits flow process begins with a meeting of all the users of the new application. Operators explain the direct impact of each application-driven capability and discuss the changes in airport operations that arise from these impacts. Subsequently, we develop concise descriptions of each operational change. The benefits flow is a diagram that serves as an outline for this narrative framework. It has four columns: *capabilities*, *direct impacts*, *outcomes*, and *benefits*. For clarity, we define these words below for our context:

Capability – what the new application provides the users

Direct Impact – how the new or improved capability enhances user operations

Outcome – the result of the direct impacts on airport/airline operations

Benefit – how the outcomes improve airport/airline operations in terms of quantifiable measures

There are a number of these benefits flow diagrams in this document. The paragraphs following each diagram describe the flow in a narrative format that includes a problem statement, describes how the application helps to solve the problem, and summarizes any evidence so far collected. The narratives are organized by outcome. If the descriptions were given in an earlier document and there is no further evidence or information at this time, we simply present the diagram without the detailed descriptions and reference the document with the detailed descriptions.

The outlines and accompanying descriptions provide a focus for the analyses presented.

2.0 SDF

2.1 System Description and History

Over the past few years, SF-21 has partnered with United Parcel Service (UPS), local Air Traffic Control (ATC), and the Regional Airport Authority to test early implementations of NAS equipment at Louisville International Airport (SDF)[5,6]. Currently, SF-21 is exploring the benefits of using Automatic Dependent Surveillance-Broadcast (ADS-B) equipment and procedures in the terminal area, and shared multilateration surveillance data on the surface. An ADS-B environment allows equipped aircraft to see surrounding aircraft on a Cockpit Display of Traffic Information (CDTI). Surface multilateration allows real-time surveillance for use by UPS ramp control and management.

2.1.1 Airport Description and UPS Operations

This section briefly describes the operational test-bed at SDF and considers some details of the UPS freight operation.

SDF is the major worldwide hub for UPS. Figure 2-1 displays a diagram of the airport surface with buildings and runways in black and taxiways and parking areas in gray. The UPS sorting facility dominates the land area between the runways. While local ATC controls all traffic on taxiways and runways, UPS controls ground traffic in the large ramp and parking areas around their facilities.

On weekdays during daylight hours, operations are divided about equally between commercial air carrier traffic and UPS two-day package air service. At night (after 11:00 pm local time), nearly all traffic into SDF is UPS overnight air service traffic. It is at night during the UPS arrival and departure pushes that SDF reaches its highest arrival and departure rates.

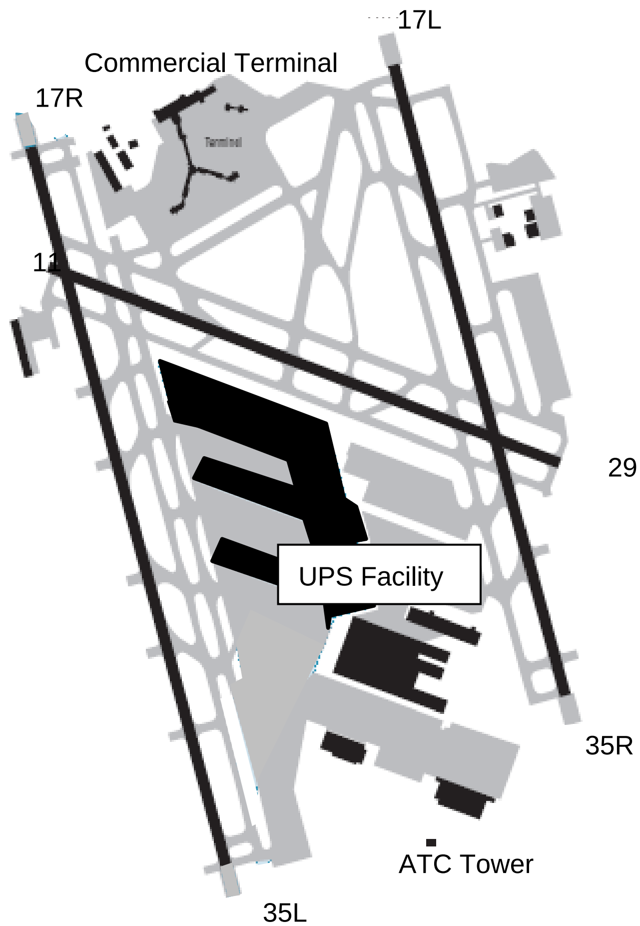


Figure 2-1. SDF surface layout

Because of the many connections necessary and the overnight time constraint, UPS must operate as peaked a schedule as possible to increase efficiency. On a typical operating night, well over 100 aircraft arrive between 11:00 pm and 2:30 am local time. The overnight packages are sorted and leave on departing flights between 4 am and 6 am. Inefficiencies in air or ground operations can lead to sort delays that can subsequently delay all outgoing flights. Increased efficiency (decreased flight or taxi time) can allow more sort time or later departure from satellite airports.

Our focus is measuring the impact of ADS-B/CDTI in the terminal area and multilateration surface surveillance data sharing. Since these systems must interact with current and future FAA and UPS equipment, SF-21 is also interested in the continuing development of related systems (i.e. ARTS IIIE, ASDE-X) and operational tests. Below we list the important changes in the system since January 2003:

- 2/2003 - Stabilized approach requirement for visual approaches into SDF changed from 500 ft. To 1000 ft.
- 4/2003 through 6/2004 - UPS installed ADS-B in 107 aircraft (75 out of 75 B757s and 32 out of 32 B767s)
- 8/2003 - SDF TRACON switched to ARTS III-E from ARTS III-A
- 10/2003 – Surface Management System (SMA) installed at UPS
- 4/2004 – UPS changes to the LIDO flight plan software
- 5/2004 – the ILS for runway 35R was out for most of May 2004
- 9/2004 - UPS and local SDF ATC started testing a new Constant Descent Approach (CDA) procedure for arrivals.

We will attempt to take these changes into account when analyzing the data to check for potential effects.

2.1.2 ADS-B/CDTI Description

ADS-B aircraft applications make use of the extremely accurate position and velocity information available now with ubiquitous Global Positioning Satellite (GPS) coverage. ADS-B aircraft automatically broadcast information once per second. Besides known GPS position, the ADS-B messages contain call sign, heading, altitude, speed, and aircraft category. Other properly equipped ADS-B aircraft and ground stations can receive these messages. The ground stations can provide controllers with additional surveillance from these ADS-B aircraft.

The CDTI is a flight deck display that presents relative position of other traffic in the vicinity with respect to one’s own aircraft using the ADS-B information. Equipped UPS aircraft receive CDTI on a multifunctional display that can also show weather and other traffic information broadcast from the ADS-B ground stations. Figure 2-2 shows a detail of the multi-functional display and gives an example of cockpit position.

Figure 2-2. Left-cockpit location of CDTI, Right-CDTI detail

Figure 2-3 details some of the traffic features available on the UPS CDTI. Specifically it focuses on information available on a user-selected aircraft. This information includes range, climb/descent rate, closure rate, and call sign, as indicated in the figure. This information is useful to pilots during airport approaches.

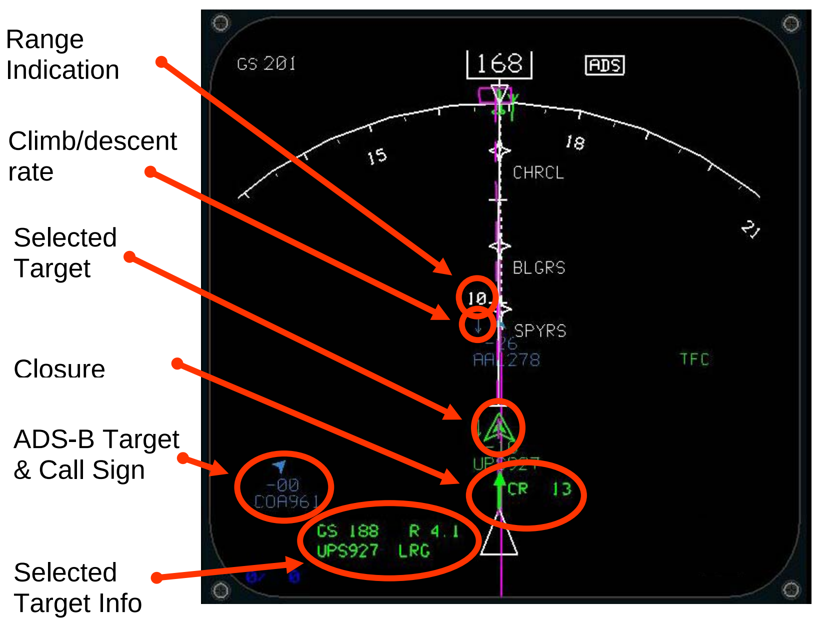


Figure 2-3. Detail of CDTI screen showing some traffic features

UPS began equipping aircraft with CDTI systems in April of 2003. They have concentrated on B-757s and B-767s because these represent the majority of the fleet (65 percent). The UPS domestic fleet consists of 75 B-757s and 32 B-767s.

Figure 2-4 shows the number of operating CDTI equipped aircraft during the installation period from March 2003 through March 2004. The top line is the total number of aircraft and the lower two are the separate counts of B757s and B767s. The dotted line that starts in June 2003 is the number of ADS-B aircraft recognized by the Comprehensive Real-time Analysis of Broadcast Systems (CRABS) tool. Johns Hopkins Applied Physics Laboratory (JHUAPL) developed the CRABS tool to record and display track information from ADS-B sensors. UPS Airbus aircraft or other non-UPS ADS-B aircraft may explain the difference between total and observed. The lines dip in November because the B767s had to undergo a system modification. The B767s came back online in late January 2004. UPS completed equipping their B757/B767 fleet (107 aircraft) in the spring of 2004.

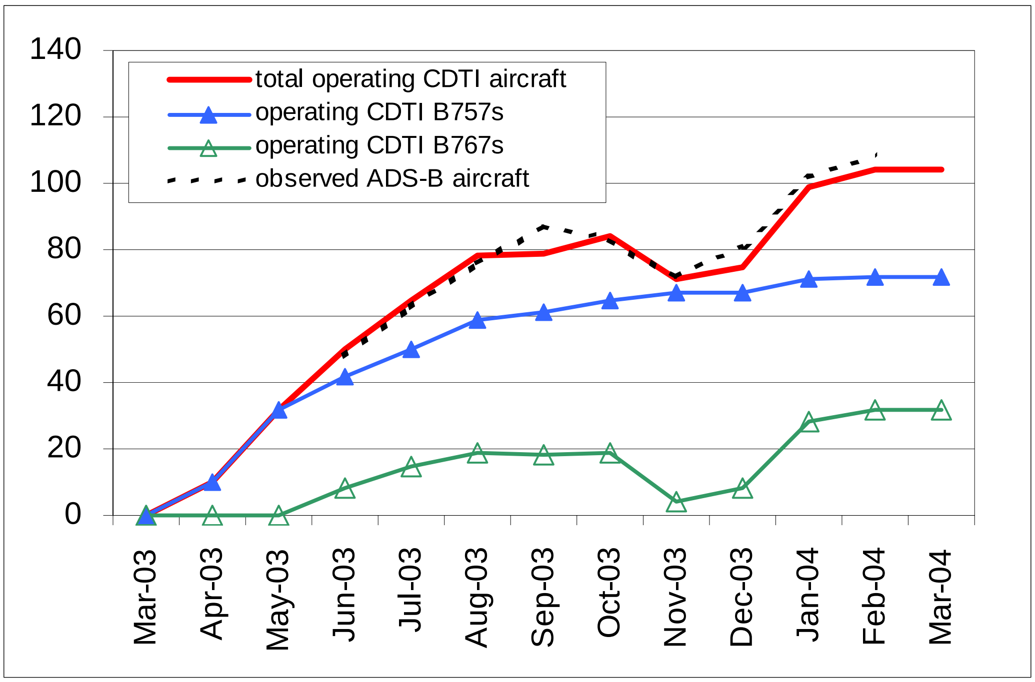


Figure 2-4. Monthly operating CDTI units from March 2003 – March 2004

2.1.3 Surface Surveillance Description

UPS has also installed displays for surveillance and identification of all transponder-equipped (not just ADS-B equipped) aircraft on the surface. The FAA Airport Detection Equipment, Model-X (ASDE-X) system and the Surface Management System (SMS) provide the data. While ASDE-X and SMS will be tools for the ATC tower in the future, the current data from this infrastructure is being shared with UPS for use in their ramp area. The system employs position data from ten ground-based receivers using multilateration. Call signs are acquired through a link to current FAA ATC terminal automation tools. UPS first used the system in their ramp control area for slower daytime surface operations in August 2004, and will begin to use surface surveillance for the night operations in the late fall.

2.2 Metrics Activities

SF-21 established a metrics working group at SDF in June 2003 to collect metrics data and other pertinent information to evaluate efficiency and safety. The group currently includes members from the FAA, NATCA, SDF ATC, the SDF RAA, and UPS.

In September 2003, the working group discussed the current operational impact of both data sharing on the surface and enhanced situational awareness/see and avoid in the terminal area. Members explained the direct impact of each capability and discussed the benefits that arise from these impacts. Subsequently, we developed "benefits flows" that outline the impacts and provide concise narrative descriptions of each benefit.

Currently, the group is collecting data and developing metrics for gauging the described benefits. The current data collection effort archives flight tracks in the air and on the surface, ATC and UPS radio frequency loads, UPS logs on surface crew times, and a large variety of operational and human factors measures.

2.3 Results

We developed separate benefits flows for the surface and the terminal area. For an explanation of the benefits flow process see section **1.3**. Figure 2-5 presents a diagram of the benefits flow for data sharing on the surface. For more details on the SDF data sharing on the surface benefits flow (including detailed descriptions of the potential benefits) see *Performance Metrics Results to Date October 2003* [2]. Operational testing of the surface surveillance system to began in late 2004. Analysis of baseline taxi data and metrics can be seen in the *FAA SF-21 SDF Metrics Update June 2004* [7]. Results and analysis after implementation will be presented in future documents.

Figure 2-6 presents a diagram of the benefits flow for enhanced situational awareness/see and avoid in the terminal area. In *Performance Metrics Results to Date April 2003* [1], we presented the terminal area benefits flow and quantified the impacts where possible. In the following sections, we summarize the previous results from [1] and present an updated analysis of flight distance and times in the terminal area.

Figure 2-5. SDF Data Sharing on the Surface Benefits Flow

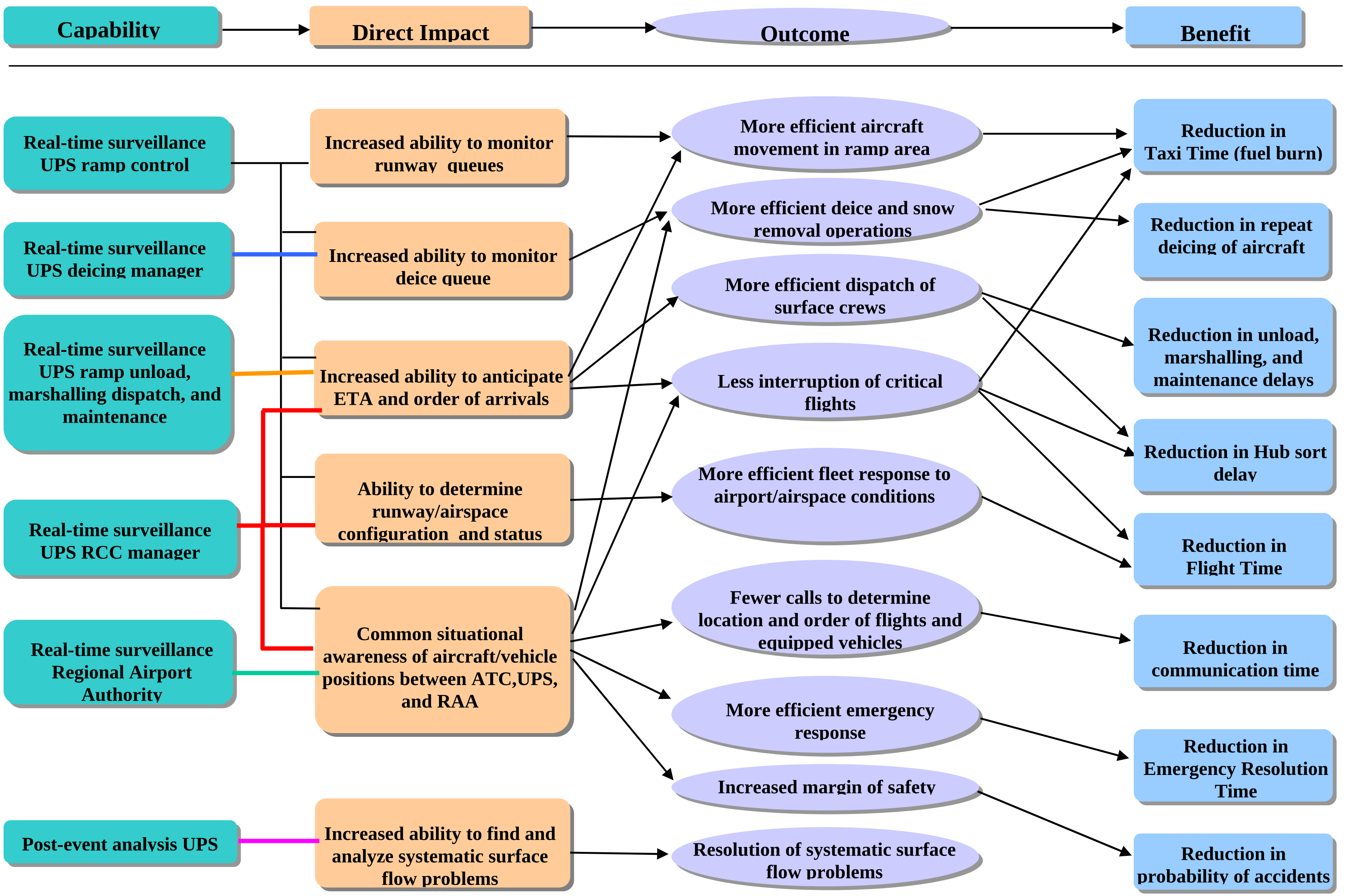
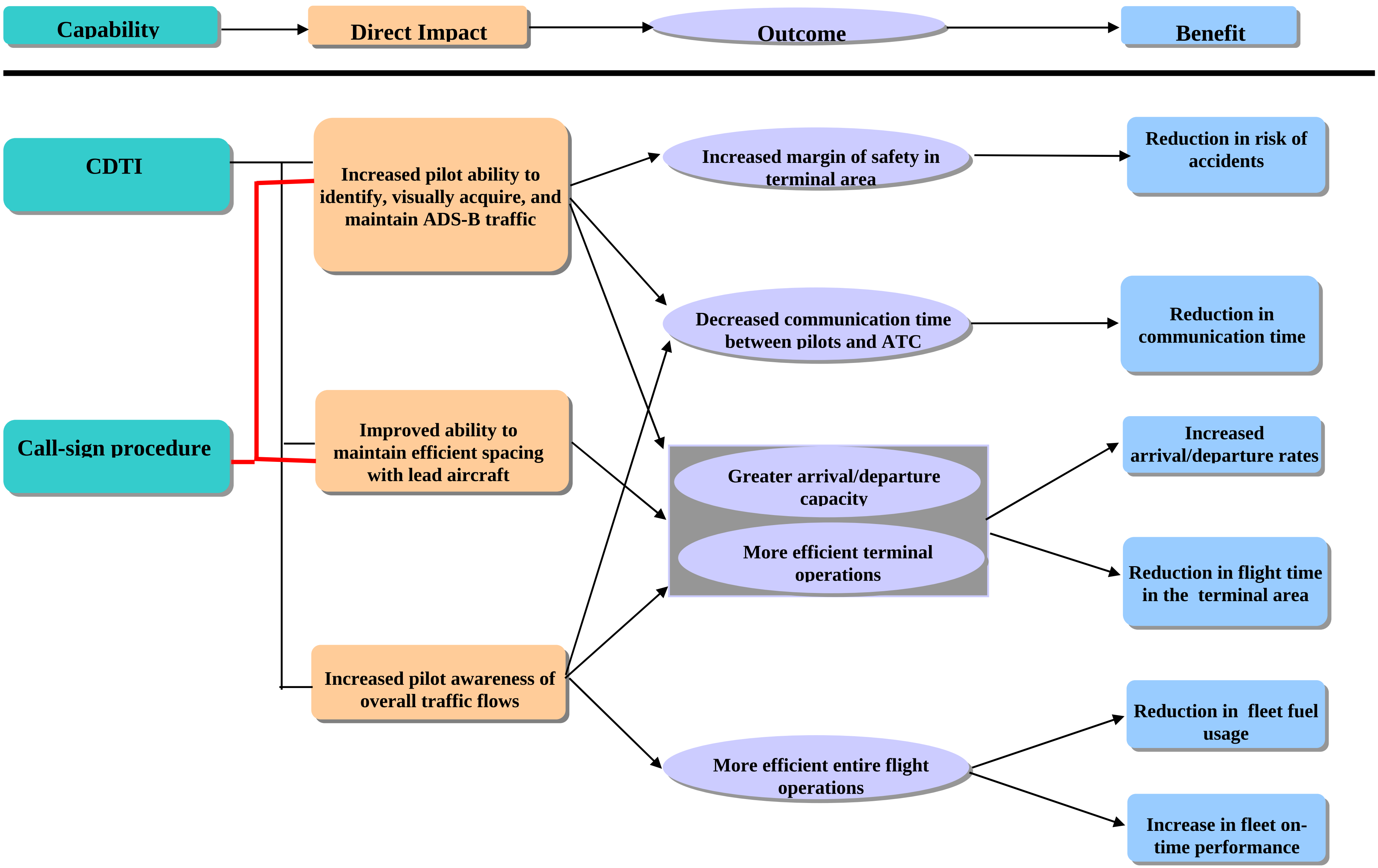


Figure 2-6. SDF Enhanced Situational Awareness/See and Avoid in Terminal Area Benefits Flow



2.3.1 Summary of Previous Results

The summaries below are organized by the benefits flow *outcomes* seen in Figure 2-6.

• Decreased communication time between pilots and ATC – We presented an analysis of audio loading on the ATC channels during the transition to ADS-B and after a majority of the UPS B767/B757 fleet had been equipped. As a measure of audio loading, we examined the total integrated area under audio loading curves. This is a measure of the total operator workload on the audio system. This total audio workload should decrease as the system becomes more efficient. The integrated audio loading for the ATC terminal frequency decreased approximately five percent in the post-implementation period.

• Greater arrival/departure capacity/More efficient terminal operations – We presented an analysis of flight times and distances for UPS arrivals into SDF. The results compared track data from the first three months of full CDTI equipage to the same three months from the year before. We update this analysis in the next section.

• More efficient overall flight operations – We presented an analysis of the difference between actual in-flight fuel burn and planned in-flight fuel burn for UPS arrivals into SDF. The results compared UPS fuel data from the first three months of full CDTI equipage to the same three months from the year before. The results showed a decrease in the difference between actual and planned fuel burn, indicating an increase in predictability. The mean percent difference of in-flight fuel burn (i.e. (actual-planned)/planned) decreased eleven percent after implementation. This analysis has not been updated because planned fuel burn numbers changed dramatically after UPS implemented new flight planning software in April 2004.

2.3.2 New Flight Distance/Time in Terminal Area Analysis

This analysis concerns the **Greater arrival/departure capacity and more efficient terminal operations** outcomes seen in Figure 2-6. Most of the benefits flow outcomes (especially the CDTI-related ones) also relate to specific CDTI applications outlined in the *Safe Flight 21 Master Plan* [3]. The current Master Plan application associated with greater terminal area capacity and efficiency is **Enhanced Visual Approach**. There are further Master Plan applications that focus specifically on efficiency during Instrument conditions. In the following subsections, we describe the mechanism for benefit in detail, and then present the analysis and results.

2.3.2.1 Benefit Mechanism Description

Visual Approaches (VAs) are the most expeditious, effective and efficient way to facilitate arriving air traffic, increasing airport capacity by as much as 50 percent over Instrument Landing System (ILS) arrivals. VAs allow Air Traffic Control (ATC) to transfer radar Instrument Flight Rules (IFR) separation responsibility (typically 3 miles-in-trail) to the aircrew, reducing separation between the same type aircraft (B-737, B-727, MD-80, A-320, etc.) to as little as 2 miles-in-trail. This procedure is well established (more than 30 years) and maximizes airport capacity while maintaining safety.

The ADS-B/CDTI **Enhanced Visual Approach** application helps to increase efficiency at the airport by allowing more VAs, and by allowing VAs to be flown in a more efficient manner. To further explain these benefits, we examine three ways in which a CDTI can directly affect user operations: (1) *Increased pilot ability to identify, visually acquire, and maintain sight of ADS-B traffic,* (2) *Improved ability to maintain efficient spacing with lead aircraft,* and (3) *Increased pilot awareness of overall traffic flows.* (Also see Direct Impact column of benefits flow, Figure 2-6.)

1) Increased pilot ability to identify, visually acquire, and maintain sight of ADS-B traffic

VAs require the flight deck crew (aircrew) to visually acquire preceding aircraft (aircraft they will follow) or the airport, prior to ATC issuance of the Visual Approach clearance. Once the VA clearance is issued, in-trail separation and maintaining visual contact with preceding traffic becomes the responsibility of the aircrew. If the aircrew cannot maintain this visual contact, it is incumbent upon them to advise ATC so another form of approved separation[1] may be achieved.

The ability of ATC to issue Visual Approaches is based on strict weather minimums. A weather ceiling of at least 500 ft. above the minimum vectoring altitude is essential for VA operations. For example, the VA weather minimums for SDF are a ceiling of 3000' and 3 miles visibility.

In many cases, however, conditions prevent ATC from operating at full VA capacity prior to reaching VA weather minimums. Weather ceilings determine VA minimums, however, pilot ability to identify and maintain visual contact with traffic and the airport surface (all critical elements in the VA) may be difficult at night or during times when scattered layers exist below the ceiling.

During peak arrival rushes, aircraft are sequenced to the airport at closely spaced intervals that allow very little opportunity for adjustment, minimizing options available to the ATC Specialist. If an aircraft cannot maintain VA separation criteria (cannot see preceding traffic), resulting in a loss of IFR separation, the aircraft is generally taken out of the final approach sequence and vectored again to the final approach course using standard IFR radar (miles-in-trail) separation. Due to airspace saturation, this is not only time consuming for the aircraft/airline, but also labor intensive for the ATC Specialist.

During such times, ATC specialists become preoccupied with traffic calls to establish visual contact between aircraft, resulting in a point of diminishing returns. To avoid compromising safety, ATC has established VA cutoff points that are, in many cases, above the VA weather minimum criteria. The value of the VA cutoff point is based on ATC Specialists' past experience, airport characteristics, and the point of diminishing returns.

The FAA Operational Evolution Plan (OEP) (see application AW-2.1 [8]) indicates the use of the CDTI is expected to assist the pilot in visually acquiring, identifying, and

[1] Approved IFR separation is radar, non-radar, or visual.

tracking an aircraft that has been referenced as traffic by ATC, so the controller may clear the aircraft for a visual approach. The CDTI accomplishes this enhancement by allowing the pilot to correlate the target aircraft and trajectory information from the CDTI to the actual traffic as seen out-the-window. Also, with faster identification of pertinent traffic, the need for additional traffic advisories by ATC or follow-on interactions between the pilot and controller is expected to decrease. We expect these changes to increase terminal area efficiency in VA conditions resulting in a reduction in flight time in the terminal area and an increase in arrival rates. No changes to FAA Order 7110.65 (Air Traffic Control) are required for this application.

The current ADS-B/CDTI terminal application is a critical building block for future applications eventually aimed at allowing ATC to continue VAs down to Visual Meteorological Conditions (VMC) minimums, which require ceilings greater than 1,000 ft and visibility greater than 3 miles.

2) Improved ability to maintain efficient spacing with lead aircraft

In current operations, pilots have no reliable means of determining the exact spacing behind the aircraft in front of them. Visual approach relies on the pilot's experience to avoid the preceding aircraft and aircraft wake, while maintaining sufficient space to ensure that the aircraft can clear the runway prior to his or her own landing. Historical studies have shown that there is a significant variation in the distances between aircraft in visual approaches [9]. The net result of such variations is excess spacing between some aircraft pairs; the accumulation of such excess leads to a lost opportunity to land additional aircraft during a period of peak arrival demand.

With CDTI, the pilot has a digital readout of range and an indication of relative ground speeds. This is expected to enable pilots to maintain better awareness of position and speed of traffic being followed and help the pilot judge more precisely the necessary control inputs to achieve a given spacing. The expected reduction in spacing variation would lead to the elimination of the lost throughput opportunities. We expect evidence of this increased efficiency to also result in a reduction in flight time in the terminal area and an increase in arrival rates.

3) Increased pilot awareness of overall traffic flows

The last CDTI impact we discuss is increased pilot awareness of the traffic flow into the airport. CDTI can display all ADS-B aircraft in the terminal area. Pilots can use this information to obtain a better idea of the overall arrival flow. This should allow the pilot to respond quickly to ATC instruction and prevent potential misunderstandings, thereby increasing efficiency. A recent email from an International Pilot Association (IPA) pilot to UPS management illustrates this point:

> "Well, I've seen the light…Last Friday night, I was flying into the SDF sort around midnight and the ADS-B/CDTI was showing almost all the inbound traffic as ADS-B equipped. The parade of inbounds could be easily seen on the screen. The reason for the occasional turn and/or speed reduction could be anticipated by a near radar-like view of the traffic surrounding us and the flow to the final segment (NAV function displayed on CDTI). The situational awareness of the ATC environment was dramatically increased…Pretty neat stuff."

2.3.2.2 Analysis Description

Our examination of terminal efficiency considers flight time and distance of UPS arrivals into SDF. We can directly relate flight time measurements to fuel burn, but the average flight time from day to day varies dramatically because of the wind. Flight distance measurements are less affected by the wind; however, they lack any speed change information.

Figure 2-7 displays flight tracks during a night of North Flow operations. The arrows point out rings at 40 nmi and 100 nmi from the airport center. We use these rings in the analysis to separate the flights into regions during approach. We also examined flight distances as far as 300 nmi from SDF, but found no measurable effect beyond 100 nmi.

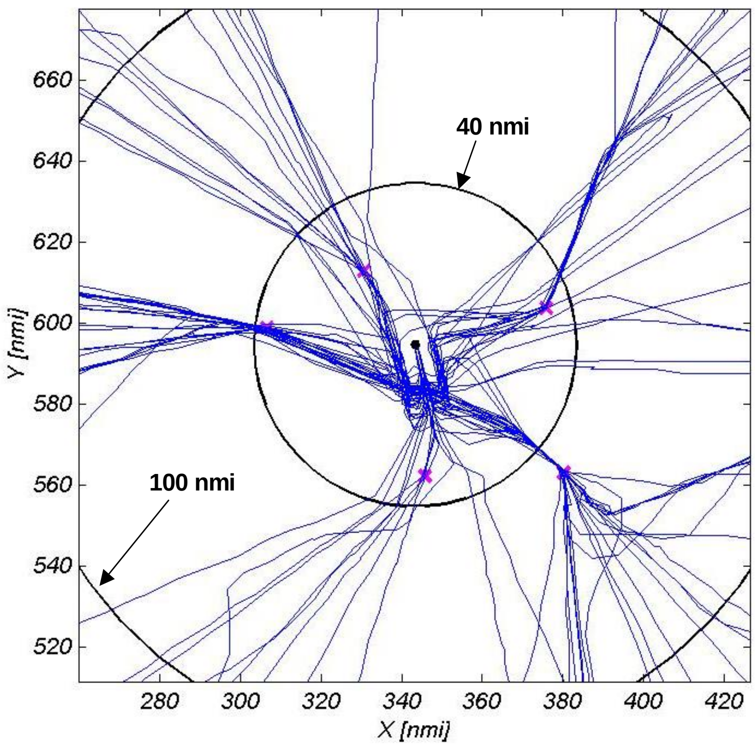


Figure 2-7. Example flight tracks during North Flow operations at SDF

The flight track calculations use three data sources. Flight tracks beyond 40 nmi use Enhanced Traffic Management System (ETMS) one-minute position data. This is data archived from the Air Route Traffic Control Center (ARTCC) Host computer system. The archived Host data is fairly accurate outside of the immediate terminal area (40 nmi), but suffers some signal loss inside of SDF TRACON airspace. Also, the many changes in speed and direction necessary for an approach may not be sufficiently captured by the one-minute tracks.

Flight tracks within 40 nmi employ two different ARTS archives. Before August 2003 we use compressed ARTS III-A data archived at the FAA Command Center. This data source became inactive after SDF installed ARTS III-E. After October 2003, we use data from the UPS SMA ARTS feed archived by JHUAPL on a monthly basis. To determine if these two archives give similar results, we compared the mean flight time and distance distributions for a day of overlap in May 2003. (We received a few days in May and June from the new data source before we were able to archive continuously). The results of the comparison found little statistical difference (well below the 95 percent level) in the flight time and distance means.

By Jan 2004, over 90 percent of the UPS B757/B767 domestic fleet included operating CDTI displays (See Figure 2-4). The B757/B767 fleet comprises 65 percent of the total UPS fleet. The metrics group decided that January 2004 would be a good starting point to observe the impacts of CDTI/Enhanced Visual Approach. The post-implementation data set begins January 1, 2004 and ends September 14, 2004. Although we had access to data after September 14, 2004, we did not want to capture impacts associated with the Constant Descent Approach (CDA) test that occurred during that time. In the following analysis we compare the post-implementation data to two different baseline data sets (see Figure 2-8). Baseline Data Set 1 does not include data from the partial equipage transition period (June – December 2003). To take seasonal demand into account, we examine the same months (January through September) as after implementation; however, to avoid the partial equipage period, the baseline data set contains data from two different years: June through September of 2002 and January through May of 2003. Baseline Data Set 2 contains flights from January through September of 2003, but overlaps the first few months of the transition period.

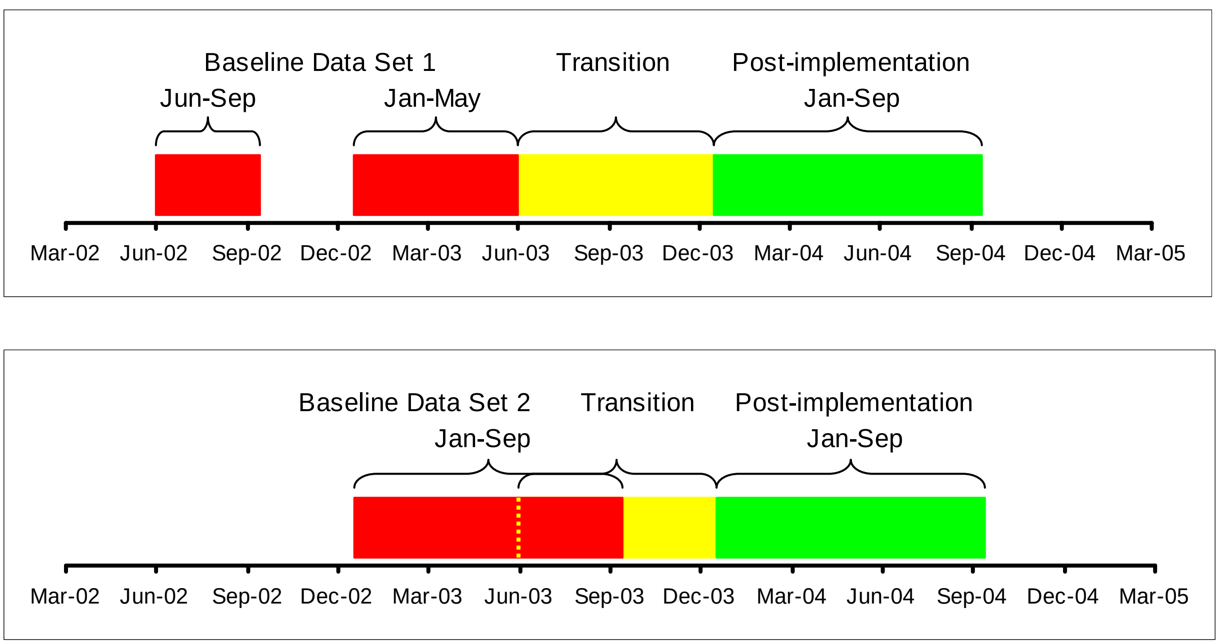


Figure 2-8. Timelines showing baseline and post-implementation data periods

First, we examine flight time and distance changes for the entire UPS fleet. Then, we narrow the focus to examine the period with the highest fraction of equipped aircraft. Figure 2-9 displays the number of SDF arrivals and the fraction of those arrivals that are

B757s or B767s in 15-minute periods throughout a day. The shaded box in Figure 2-9 indicates the arrival peak with the maximum percentage B757/B767 traffic. This peak period occurs between 1:30 am and 2:30 am local time (between 2130 and 2230 GMT during Daylight Savings and between 2030 and 2130 otherwise.) CDTI use should affect the flow in both full and mixed equipage scenarios, but we expect the magnitude of the effect to be greater during times of high equipage.

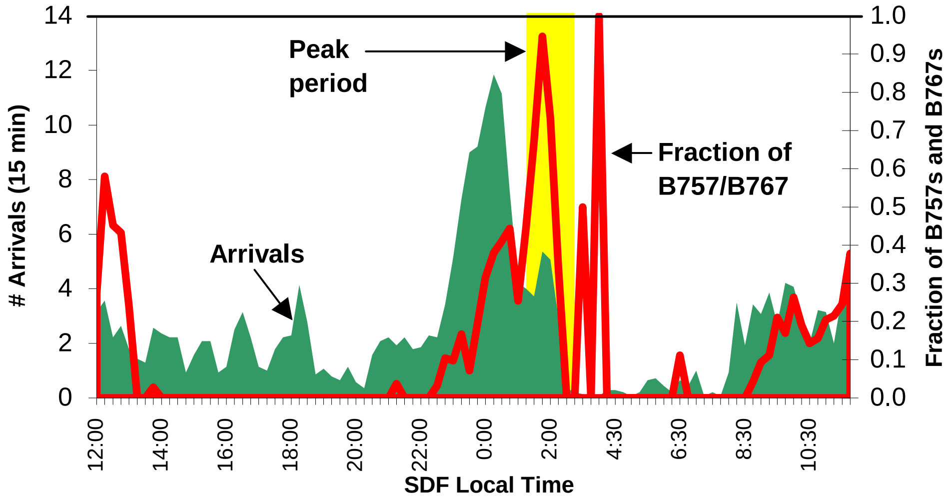


Figure 2-9. Average SDF Arrivals (15 min) and Fraction of B757/767s showing peak period

To take airport configuration into account, we bin the data by runway configuration. SDF primarily operates in one of two runway configuration modes: North Flow and South Flow. During a particular configuration, most of the flights arrive and depart facing the direction of the flow. SDF determines airport flow based on winds, runway conditions, and noise abatement procedures.

We separate weather data into instrument (IA) and visual (VA) approach conditions based on the time of arrival compared with weather reports from the Aviation System Performance Metrics (ASPM) database. Since we do not have access to actual approach records, we cannot be sure that visual or instrument approaches were being implemented at a specific time. However, we assume that a majority of the flights use instrument approaches during the defined IA conditions, and visual during the defined VA conditions. ASPM defines the conditions based on SDF facility input to be running IA when the ceiling is less than 3000 ft or the visibility is less than 3 nmi.

2.3.2.3 Analysis Results

Figure 2-10 displays the distance savings (difference in means between baseline and post-implementation periods) from 40 nmi to the runway using Baseline Data Set 1. There are separate results for all UPS flights, UPS flights during the B757/767 peak period, and non-UPS flights for comparison. We show results for each runway configuration/weather condition pair. All results represent a difference in the mean values that is significant to at least the 95 percent level, as determined by an independent samples T-test. If the difference in the means was not determined to be significant to the 95 percent level, we did not include the value.

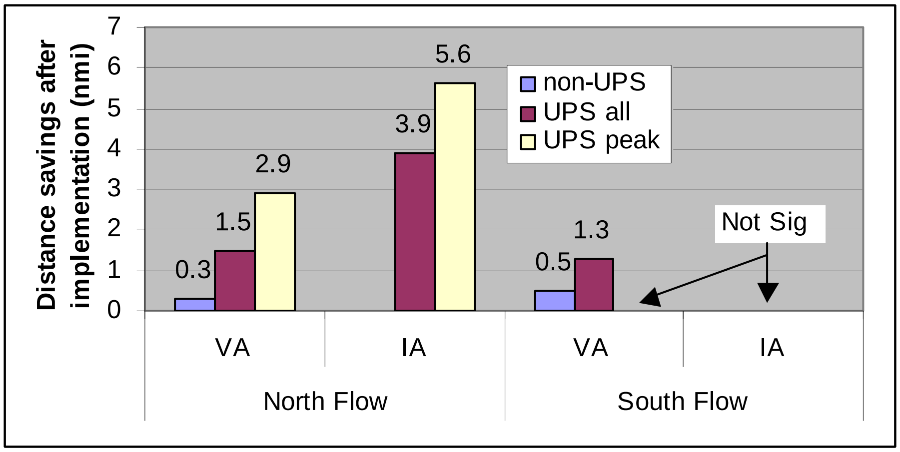


Figure 2-10. Flight distance savings 40nmi-runway using Baseline Data Set 1

For the North Flow configuration, we see significant flight distance savings for all UPS flights and UPS flights during the B757/767 peak in both weather conditions after CDTI implementation. As expected, the results for the high equipage case (UPS peak) are of greater magnitude than the mixed equipage case. While the non-UPS traffic at SDF has also seen some savings, these savings are not as large as exhibited by the UPS flights.

During South Flow, the results are not as clear. There may be some flight distance savings for UPS flights during VA conditions, but no significant savings were detected during the peak period. Also, no significant changes were found in South Flow IA conditions for any of the data sets.

Table 2-1 presents the flight distance and time values as well as the percentage of flights that flew during each runway configuration/weather condition pair. We believe the flight distance difference may represent a better estimate of savings than flight time; flight time values are heavily affected by local wind speed and direction. The percentage values can be used to gauge how often the savings are applicable. The data shows that North Flow is the dominant configuration during UPS operations and South Flow is the dominant configuration during non-UPS operations. This difference is due in large part to noise abatement procedures necessary for night operations at SDF.

Table 2-1. Flight distance and time savings 40nmi-runway using Baseline Data Set 1

Data Set 1	Metric	Non-UPS flights	All UPS flights	B757/767 peak UPS flights
VA North	**Dist Savings**	0.3 nmi	1.5 nmi	2.9 nmi
	Time Savings	17 sec	16 sec	40 sec
	% flights in config	31%	51%	61%
IA North	**Dist Savings**	Not Sig	3.9 nmi	5.6 nmi
	Time Savings	Not Sig	57 sec	76 sec
	% flights in config	8%	11%	11%
VA South	**Dist Savings**	0.5 nmi	1.3 nmi	Not Sig
	Time Savings	25 sec	21 sec	Not Sig
	% flights in config	52%	32%	24%
IA South	**Dist Savings**	Not Sig	Not Sig	Not Sig
	Time Savings	Not Sig	Not Sig	Not Sig
	% flights in config	9%	6%	4%

Figure 2-11 and Table 2-2 present similar results using Baseline Data Set 2. The Data Set 2 results are not identical to the Data Set 1 results, but follow the same trend. The one difference is that the peak UPS case for South Flow/VA conditions shows some savings. Unlike the other results, the "UPS peak" savings are lower than the "UPS all" flights savings.

We also examined flight times and distances from 100 nmi to 40 nmi for both baseline data sets. While we saw some similar trends in the 100 nmi to 40 nmi data, the differences in the means were small and not statistically significant to the 95 percent level.

Results from both baseline data sets show a decrease in flight distances in the terminal area after CDTI implementation. These savings are most apparent during North Flow operations. Flights arriving during the high equipage peak accrue larger savings than those in the mixed equipage periods. The distance savings for UPS flights is significantly larger than for non-UPS flights at SDF during the same time period.

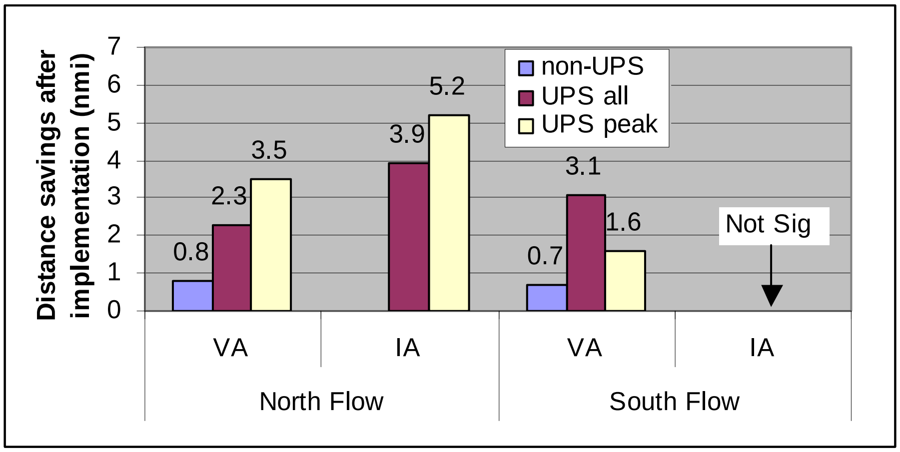


Figure 2-11. Flight distance savings 40nmi-runway using Baseline Data Set 2

Table 2-2. Flight distance and time savings 40nmi-runway using Baseline Data Set 2

Data Set 2	Metric	Non-UPS flights	All UPS flights	B757/767 peak UPS flights
VA North	**Dist Savings**	0.8 nmi	2.3 nmi	3.5 nmi
	Time Savings	31 sec	37 sec	51 sec
	% flights in config	30%	51%	60%
IA North	**Dist Savings**	Not Sig	3.9 nmi	5.2 nmi
	Time Savings	Not Sig	60 sec	68 sec
	% flights in config	10%	11%	12%
VA South	**Dist Savings**	0.7 nmi	3.1 nmi	1.6 nmi
	Time Savings	26 sec	53 sec	24 sec
	% flights in config	52%	32%	24%
IA South	**Dist Savings**	Not Sig	Not Sig	Not Sig
	Time Savings	Not Sig	Not Sig	Not Sig
	% flights in config	9%	6%	5%

3.0 EAST COAST AND ERAU

3.1 System Description and History

The SF-21 Flight Safety Application Group focuses on stimulating production and self-equipage of ADS-B for the general aviation community.

Through agreements with several states along the East Coast, the Flight Safety group has begun to provide ground infrastructure that will support ADS-B services. By the end of 2004, they hope to provide free traffic and weather information from 25 ADS-B ground stations. This information will be available to anyone equipped with ADS-B displays. They also support ADS-B implementation at Embry-Riddle Aeronautical University (ERAU) in Prescott, Arizona and Daytona Beach, Florida. Both the Prescott and Daytona Beach campuses started using ADS-B displays in late summer 2004.

3.2 Metrics Activities

The metrics team met with representatives of the Aircraft Owners and Pilots Association (AOPA) in November 2003 to discuss benefit descriptions for general aviation. The metrics team also visited ERAU at Daytona Beach in September 2004 to discuss gauging the impacts of ADS-B. ERAU already gathers much data that may be valuable as baseline data for the benefits process and has shared some of this data with SF-21. We will begin analysis of changes in activity as use at these sites increases.

In an effort to count increases in the number of current ADS-B users (GA and air carrier) that could use SF-21 services, Johns Hopkins Applied Physics Lab (JHUAPL) began monitoring ADS-B aircraft from available sensors. They used data from sensors in Louisville, KY, Atlantic City, NJ, Edenton, NC, the Alaska Capstone Program, and Milwaukee, MN. They measured unique identifiers detected on a monthly basis from aircraft and equipped ground vehicles.

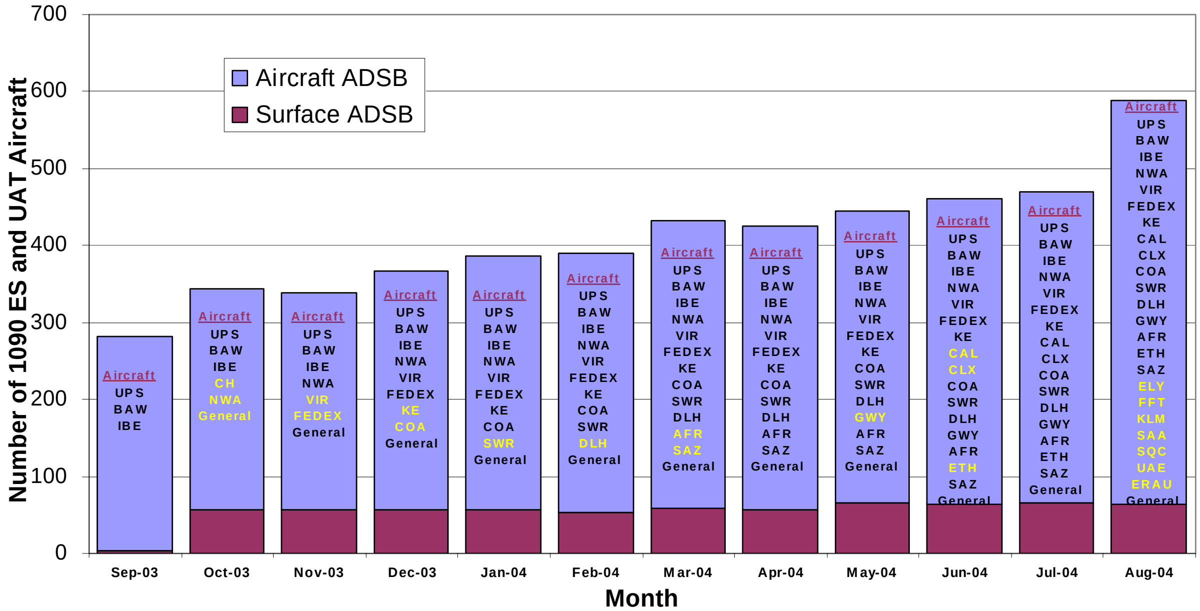


Figure 3-1. Number of observed ADS-B aircraft and vehicles from Sep 2003 through Aug 2004

Figure 3-1 displays the monthly count of unique identifiers. The chart indicates the ratio of aircraft to surface vehicles and lists airlines and groups of aircraft represented in the month. The light gray names in the list represent airlines that appear on the list for the first time during that particular month. GA aircraft and many small Alaska companies are denoted by the word "General." The larger airlines are listed by the call signs below:

- AFR – Air France
- BAW – British Airways
- CAL – China Airlines
- CLX – Cargolux Airlines
- COA – Continental Airlines
- DLH – Lufthansa
- ELY – El Al Israel Airlines
- ERAU – Embry-Riddle Aeronautical University
- ETH - Ethiopian Airlines
- FAA – Federal Aviation Administration
- FFT – Frontier Airlines
- FEDEX – Federal Express
- GWY – USA 3000 Airlines
- IBE – Iberia Airlines
- KE – Korean Airlines
- KLM – KLM Royal Dutch Airlines
- NASA – National Aeronautics and Space Administration
- NWA – Northwest Airlines

- SAA – South African Airways
- SAZ – Swiss Air-Ambulance Ltd.
- SQC – Singapore Airlines Cargo
- SWR – Swiss International Airlines
- UAE – Emirates Air
- UPS – United Parcel Service
- VIR Virgin Atlantic Airlines.

4.0 GULF OF MEXICO

4.1 System Description and History

The SF-21 En route and Oceanic Application Group focuses on developing ADS-B applications for use in areas with no radar coverage, such as the Gulf of Mexico.

In March of 2003, the En route and Oceanic Group began a concerted effort to identify future benefits for ADS-B in the Gulf of Mexico. The current effort in the gulf involves estimating future benefits, not measuring current benefits of any deployed tool. However, cooperation of the cost/benefit and metrics teams is essential to provide a consistent story throughout the life cycle of a project. To this end, the ATO Technology Development Metrics Team is assisting in the benefits identification process and will be active in gathering and analyzing baseline data for this effort.

4.2 Metrics Activities

In the spring of 2003, Technology Development started to develop benefits flows (much like those described at other sites) in coordination with Continental Airlines, Houston ARTCC, NATCA, and representatives of the helicopter industry.

In the *Performance Metrics Results to Date April 2004* [1], we presented the current Gulf of Mexico benefits projections. The metrics team will assist in further projections as requested.

5.0 DFW

5.1 System Description and History

As part of the Runway Incursion Reduction Program (RIRP), the FAA installed an Airport Surface Detection Equipment - Model X (ASDE-X) multilateration (MLAT) system on the east side of Dallas-Fort Worth International Airport (DFW). NASA later installed ASDE-X on the west side as part of a data collection program. The Airport has been making these systems permanent in order to satisfy a commitment made to the FAA for mitigation of visibility restrictions to the Center Airport Traffic Control Tower caused by airport development. The ASDE-X provides both surveillance and identification of all transponder-equipped aircraft and vehicles on the airport surface. The DFW ASDE-X MLAT installation will demonstrate the performance and effectiveness of current multilateration surveillance technology. The installation will also serve as a long-term test bed for runway safety technologies, such as Runway Status Lights (RWSL), which will begin an operational evaluation in February 2005.

In March 2002, the FAA gained the support of American Airlines, Delta Air Lines, and the DFW Airport Board to determine potential benefits in efficiency and safety associated with surface surveillance data sharing. The FAA agreed to provide a real-time MLAT data feed to the participants along with the necessary equipment, communications links, and training. The prototype MLAT data sharing began in May 2002 and became available for consistent use in November 2003.

Surface surveillance displays are currently located in the American Airlines Systems Operations Center (SOC), the American Airlines ramp tower, the American Airlines Headquarters, the Delta Air Lines ramp tower, and the DFW Airport Board operation center, NASA Ames, and the DFW Airport Emergency Operations Center (EOC). Displays for FAA users in the DFW ATC control towers, and in the TRACON will be available when the ASDE-X system is commissioned.

While the FAA will continue to share data from ASDE-X with the airlines and the airport board at DFW indefinitely, FAA funding for airline and airport board equipment, communication links, and training will end in December 2004. At that time, the airlines and the airport board will decide the value of this data to their operations and negotiate with individual contractors as necessary to continue operations.

5.2 Metrics Activities

In December 2003, we held a meeting with all the interested parties to discuss the operational impact of surface surveillance data sharing. The attendees included representatives from American Airlines, Atlantic Southeast Airlines (a Delta subsidiary), Dallas/Fort Worth Airport, Delta Air Lines, the NASA North Texas Station (NTX), the FAA, associated contractors, and union representatives. Attendees explained the direct impact of each shared data capability and discussed the potential benefits that arise from these impacts.

We found that the in addition to the surface surveillance data, American and Delta also have some access to shared terminal area flight data through a Center TRACON Automation System (CTAS) feed provided by NASA. The CTAS displays aircraft tracks close to the airport and estimated runway (On) times. This data can be used to accurately estimate gate (In) times. Because the CTAS and surface surveillance displays have similar benefit mechanisms, we examine both within this study. NASA performed a study of the use of CTAS in the American Airlines Systems Operations Center (SOC) in 1999[10] and a study of the CTAS display in the Delta ramp tower in 2002[11]. We list results from both of these studies where appropriate.

In March 2004, we visited American Airlines, Delta Air Lines, and the DFW Airport Board separately to discuss ongoing use of the tools and analyses. We revisited American Airlines and Delta Air Lines facilities in September 2004 to receive an update of surveillance activities. For unrelated financial reasons, Delta Air Lines will discontinue use of their DFW hub operation in January 2005. As part of this change, Delta will no longer control the Terminal E ramp traffic.

5.3 Results

After the initial metrics meeting, we developed a benefits flow. For an explanation of the benefits flow process see section **1.3**. We created separate benefits flows for the airlines and the airport board because they had somewhat different uses of the tool. Figures 5-1 and 5-2 display the graphical representations of the benefits flow for the airlines and the airport board, respectively.

In *Performance Metrics Results to Date April 2003* [1], we presented the benefits flow and attempted to quantify the impacts where possible. Below, we summarize the previous results from [1], present an updated analysis of Delta Air Lines taxi times at DFW, and add descriptions of future applications planned by American Airlines.

5.3.1 Summary of Previous Results

The summaries below are organized by the benefits flow *outcomes* seen in Figure 5-1.

• More efficient aircraft movement in the ramp area – We presented an analysis of taxi-out times for Delta Air Lines before and after implementation of surface surveillance in the ramp tower. The analysis used four months of baseline and post-implementation data. The results showed that in Visual Approach conditions (VA), Delta taxi-out times decreased on average 30 seconds per aircraft. This decrease in times was more impressive when one considers that taxi-out times for the other airlines at DFW during the same period increased by at least a minute. We also summarized results from past NASA studies [10,11] that examined the accuracy of estimated runway On times and gate In times before and after the implementation of CTAS in the American SOC and the Delta ramp tower. The increase in accuracy positively affects the ability of controllers to pre-plan arrivals and departures in the ramp area.

Figure 5-1. DFW Data Sharing Benefits Flow - Airlines

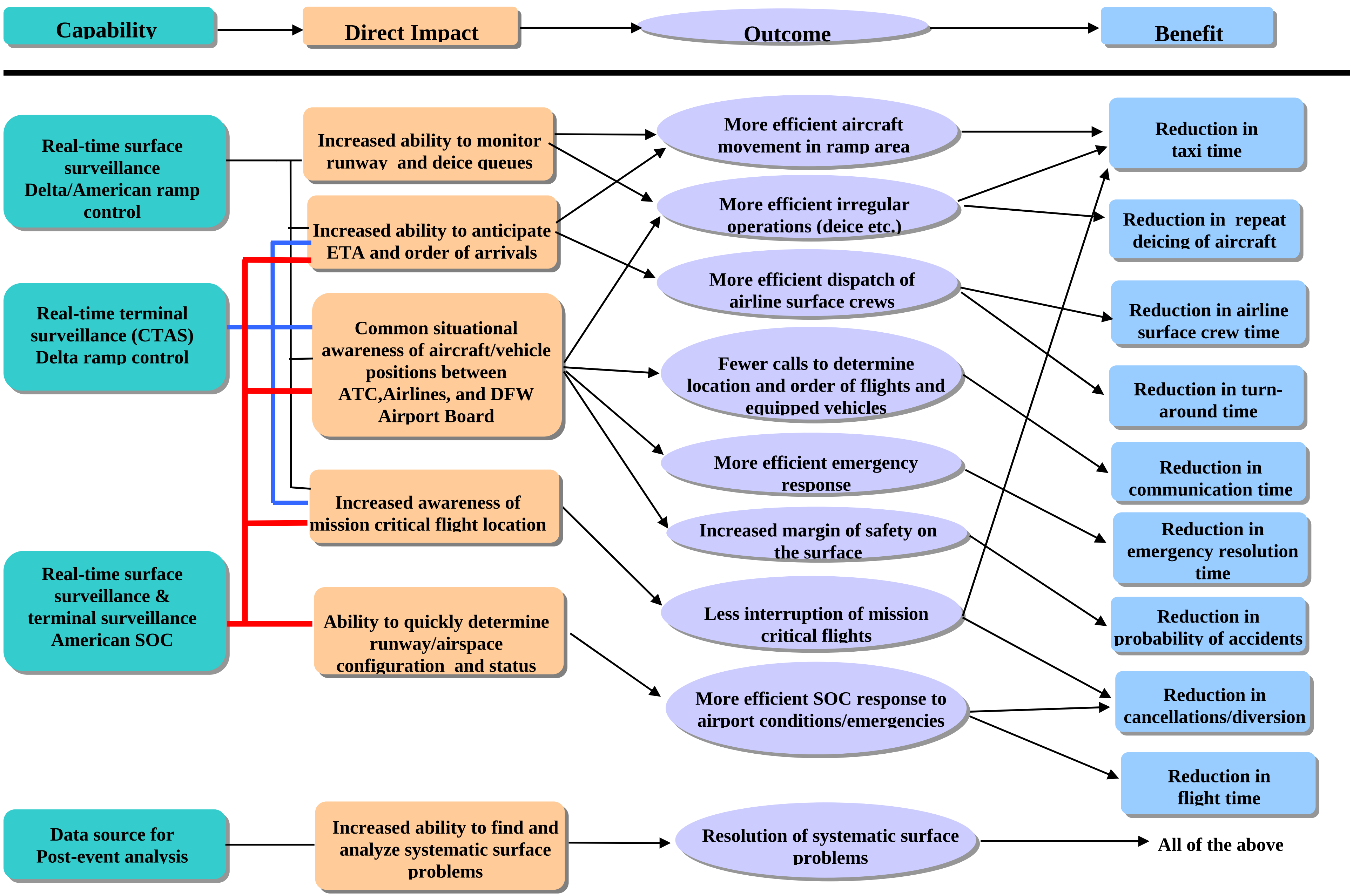
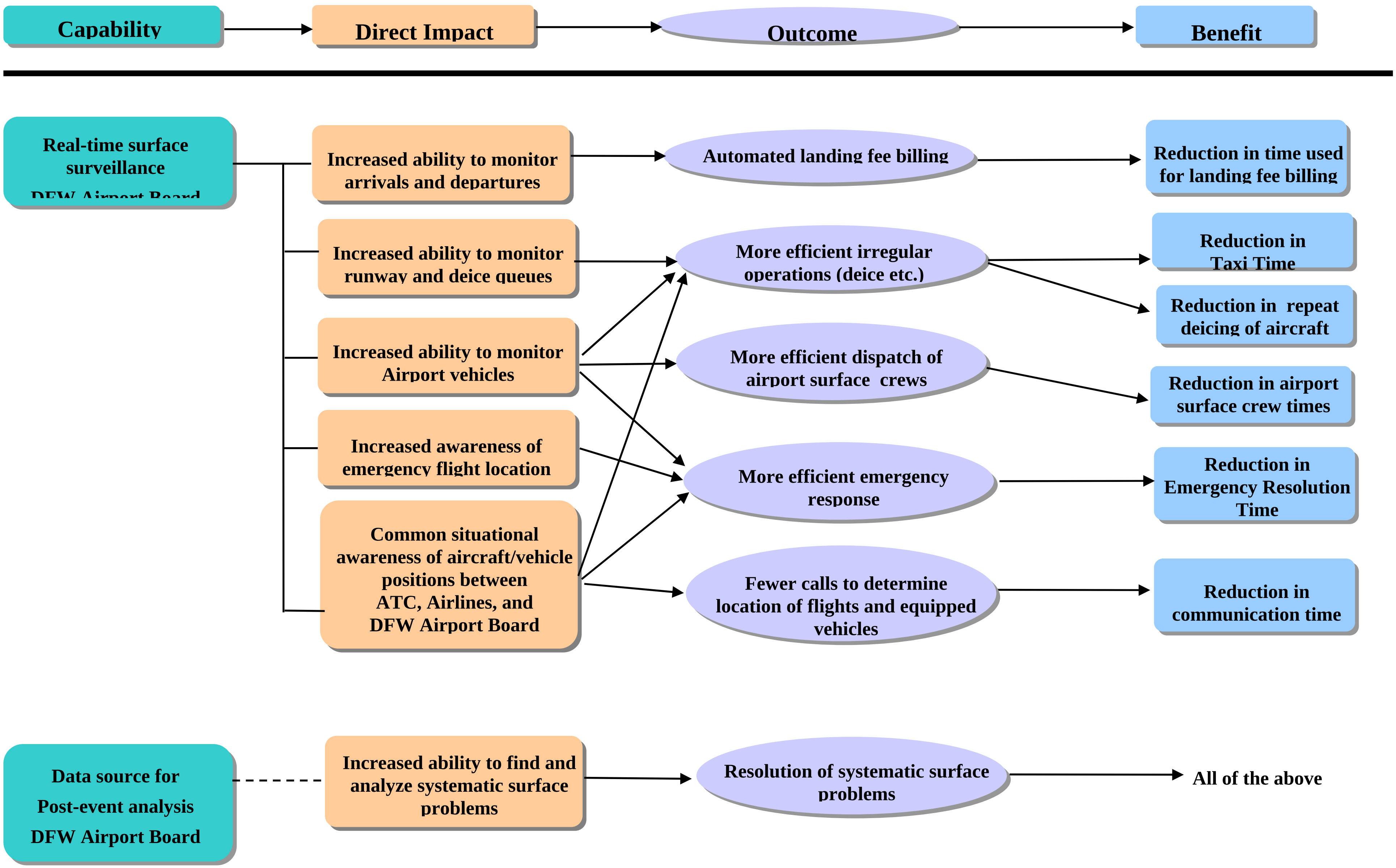


Figure 5-2 DFW Data Sharing Benefits Flow – Airport Board



• More efficient dispatch of surface crews – The inclusion of surface surveillance supported a change at the DFW Delta ramp from gate-based operations to task-based operations. Instead of a surface crew being responsible for the operations of one gate, the crew is tasked on an as needed basis at any number of gates. This system depends on the ability of the ramp tower to accurately determine aircraft locations in real-time, as provided by the CTAS and surface surveillance displays.

• Fewer calls to determine location and order of flights – Delta reported that they decreased the number of calls between pilots and the ramp tower during an arrival from two to one. They credit the reduction in calls to the availability of accurate landing information from CTAS and a reduction in non-ACARS aircraft.

• Less interruption of mission critical flights – We listed anecdotes from past NASA studies that examined diversion prevention and reaction time to diversions due to CTAS display use.

• Resolution of systematic surface flow problems – We mentioned that American Airlines installed three new surface surveillance displays in their headquarters building to examine surface tracks for use in analysis.

5.3.2 New Taxi-out Time vs. Queue Length Analysis

More efficient movement in the ramp area

<u>Problem:</u> Due to the lack of real-time surveillance, airline ramp controllers have limited ability to determine location, order, and status of inbound and outbound flights (especially true for non-ACARS flights). This limited ability results in inefficient ramp movement.

<u>Capability/Direct Impact:</u> Real-time surface and terminal surveillance provides ramp controllers an increased ability to anticipate the ETA and order of arrivals and an increased ability to monitor runway departure queues.

<u>Outcome/Benefit</u>: These impacts should aid the ramp controller in proactively controlling gate out times and deconflicting multiple inbound and outbound flows resulting in less delays and more efficient aircraft movement in the ramp area. More efficient aircraft movement in the ramp area should reduce taxi time for many flights.

<u>Evidence</u>: The Delta tower started receiving a multilateration surface surveillance feed in April 2003. The system was made stable for consistent use by November 2003. We examine taxi times before and after implementation to try and gauge an impact of this new information. The analysis is similar to that performed in [1], but uses ten months of baseline and post-implementation data as opposed to only four months.

We use ARINC Communications and Address Reporting System (ACARS) OOOI (Out Off On In) data, runway configuration data, and weather data all recorded on the Airport System Performance Metrics (ASPM) database. While we are interested in all the flights controlled by the Delta ramp tower (all Terminal E flights except Northwest Airlines), we only have consistent ACARS data from Delta flights. Note we do **not** use all the ASPM taxi times recorded in the database, only those that have verified ACARS data. The non-ACARS taxi times are estimates based on historical data, and can be incorrect by several minutes. We compared a sample of ASPM non-ACARS taxi times to a sample of airline data for the same flights and found that the ASPM non-ACARS taxi times were two minutes longer on average and the difference distribution had a standard deviation of seven minutes.

The baseline period data set contains dates between 12/1/2002 and 9/30/2003. The post-implementation data set includes data from 12/1/2003 through 9/30/2004. In November 2002, American Airlines (the dominant carrier at DFW) changed their number of arrival and departure peaks. This dramatically decreased average taxi times for all carriers at DFW. Since we thought that the effect of this depeaking operation would have dominated any change seen in the taxi data, we chose to only examine times after this event.

During the period of measurement the traffic at DFW increased considerably. Figure 5-3 displays the monthly departures at DFW from November 2002 through September 2004. The trend line shows the steady increase in demand at DFW over the past two years. Comparing the number of departures in the first nine months of 2003 and 2004 we find a seven percent increase. We will comment on the consequences of this increase later.

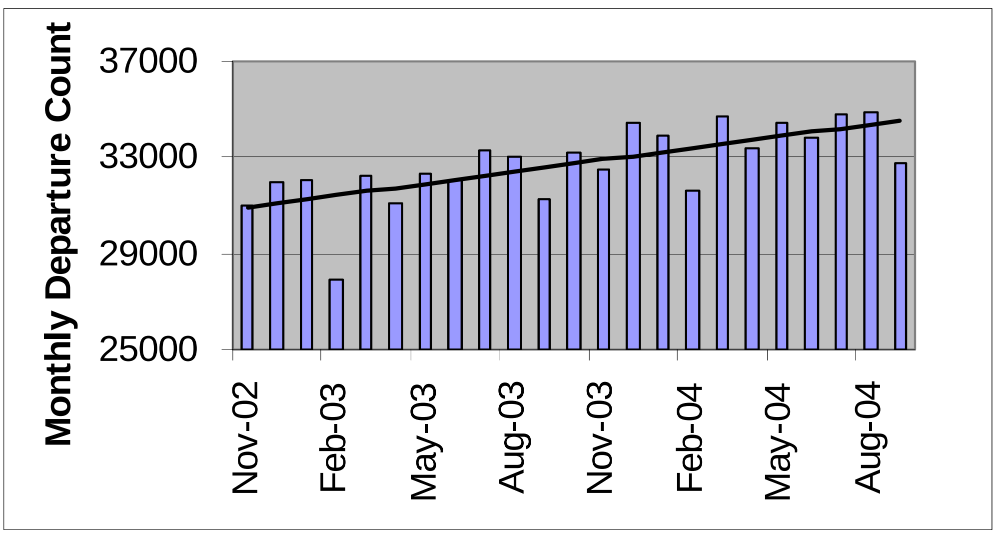


Figure 5-3. Diagram of DFW terminals and runway locations

ASPM also records runways in use (from facility logs) for each fifteen-minute period in a day. The recorded data lists each of the open runways, but DFW primarily operates in one of two runway configuration modes: North flow and South flow. During a particular flow, most of the flights arrive and depart facing the direction of the flow. Since Delta (Terminal E) is located on the South side of the airport, departures during a South flow must taxi all the way to north end of the airport to takeoff. Consequently, we expect that taxi-out times during a South flow will be longer than during a North flow.

Figure 5-4 is an overhead view of the airport surface with runways and terminals in black and taxi and ramp areas in gray. In the analysis we separate flights into North or South flow operations. For the time periods examined, DFW operated in South flow 68.6 percent of the time and in a North flow 31.4 percent of the time.

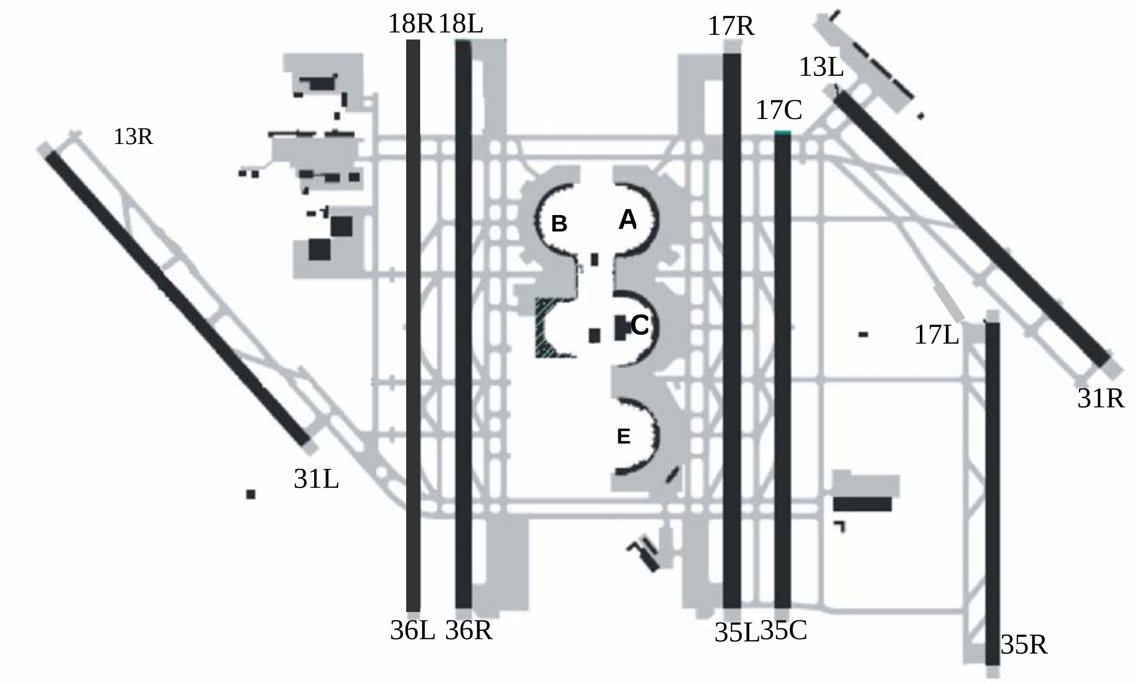


Figure 5-4. Diagram of DFW terminals and runway locations

The last factor we consider is the weather. ASPM records airport surface visibility and ceiling. From these variables, there is an algorithm based on facility input that divides the weather into Instrument Approach conditions (IA) or Visual Approach conditions (VA). To qualify for VA, the visibility must be greater than five miles, and the ceiling must be greater than 3500 feet. While this is a gross simplification of weather effects, this division should help isolate periods of relatively good and bad weather. We expect that average taxi times will increase during bad weather.

For the time periods examined, DFW operated in VA conditions 81.5% of the time and in IA conditions 17.5 percent of the time.

Figure 5-5 displays the difference in mean taxi-out time after implementation of surface surveillance (as compared to baseline period). A negative mean value indicates a reduction in taxi time. The graph shows separate measures for Delta and non-Delta flights at DFW, and separates data by airport weather conditions and runway configurations. The error bars represent the 95 percent confidence interval around the difference in the means as determined by an independent samples T-test. If the confidence interval does not include zero, the difference in the means is significant to the 95 percent level.

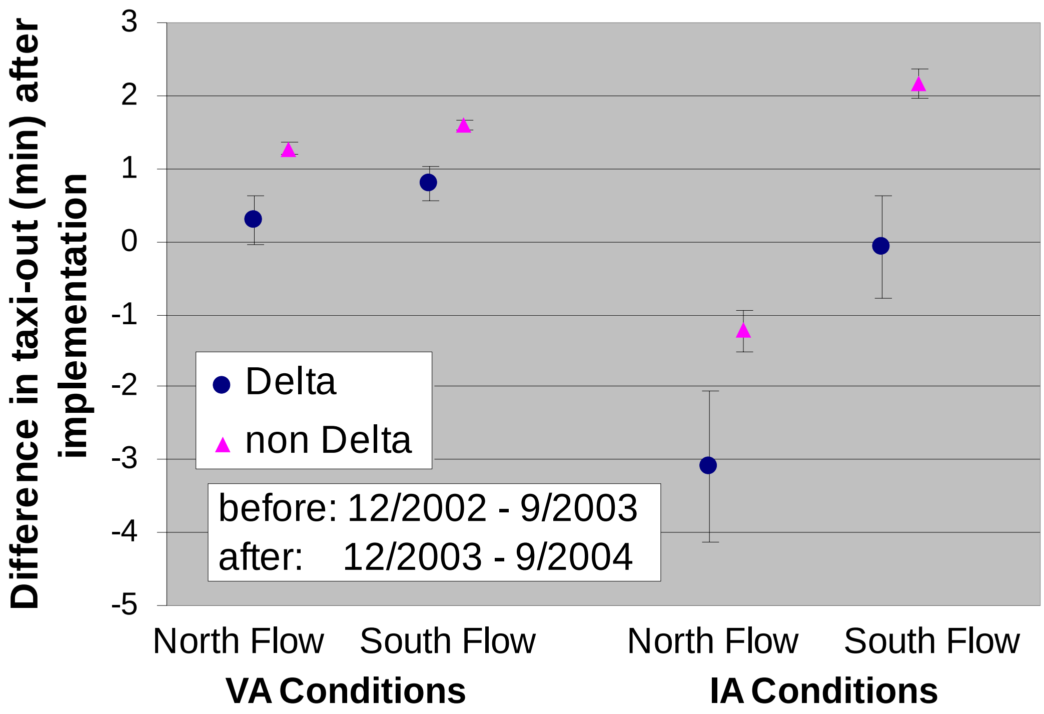


Figure 5-5. Difference in taxi-out time after implementation

Most of the results for both Delta and non-Delta flights show increases in the average taxi time after implementation of surface surveillance in the Delta ramp tower. We believe these increases are due in large part to the increase in traffic referred to earlier. The difference between Delta and non-Delta traffic is in severity of the taxi time increases. For example, during VA conditions in North Flow configuration the mean taxi-out time for Delta flights increased by a third of a minute, but the mean taxi-out time for non-Delta traffic increased by a minute and a third. This trend continues for each of the condition-configuration sets. Where taxi times for non-Delta flights increased, Delta flights did not increase as much. In the one case where taxi times decreased in the post-implementation period, the mean Delta taxi-out time decreased by 3 minutes, while the non-Delta mean taxi-out time decreased by only a little over one minute.

The reason for the large variation in IA conditions may lie in the fact that all IA condition weather is not equal. For example, there may have been more severe ice storms in one winter compared to the other. Our analysis would not capture differences in weather severity.

Table 5-1 presents a summary of the differences seen in the graphs.

Table 5-1. Summary of Delta taxi-out changes at DFW

	Taxi-out Change (min)			
	North Flow, VA	**South Flow, VA**	**North Flow, IA**	**South Flow, IA**
Delta	**+0.3**	**+0.8**	**-3.1**	**-0.1 (Not sig)**
DFW (non-Delta)	**+1.3**	**+1.6**	**-1.2**	**+2.2**

Another way to examine surface efficiency is in relation to surface queue length. A recent study [12] found the main factor determining taxi-out time was queue length. We do not have enough information to determine specific runway queue lengths over the time spans involved. However, if we define the queue for an aircraft to be the number of takeoffs between an aircraft's pushback and takeoff, we can have a general measure of airport busyness that should relate to runway queues.

Comparing taxi-out time to queue length should allow us to examine surface performance in more detail. The queue length accounts for demand better than the mean data and also incorporates weather. However, we still divide the data into different sets by airport configuration to account for difference in terminal location. The output is a curve showing mean taxi-out times for each queue length.

Figure 5-6 shows the mean taxi-out time during South Flow for Delta flights versus queue length before and after implementation of the ASDE-X display. The curves are quite similar until the queue length reaches forty-five. After forty-five, all the points on the post-implementation curve lie beneath the baseline curve. This implies that Delta flights performed better at busy times after ASDE-X implementation.

Figure 5-7 displays the mean taxi-out time during South Flow for Delta and non-Delta flights after ASDE-X implementation. For zero queue length, the Delta taxi-out time starts higher. During a South Flow configuration, all flights must taxi to the north end of the airport to takeoff facing south. Since Delta operates out of Terminal E (see Figure 5-4), Delta flights must taxi a further distance, on average, than aircraft from the other terminals. As the queue length grows, the difference between the average taxi-out time between Delta and non-Delta traffic decreases. The taxi time vs. queue length curves cross at approximately forty aircraft. After forty, all the points on the Delta curve lie beneath the non-Delta curve. This implies that Delta flights performed better at busy times than non-Delta flights after ASDE-X implementation. These queue results support the supposition that the ASDE-X feed in the Delta ramp tower has positively impacted Delta operations.

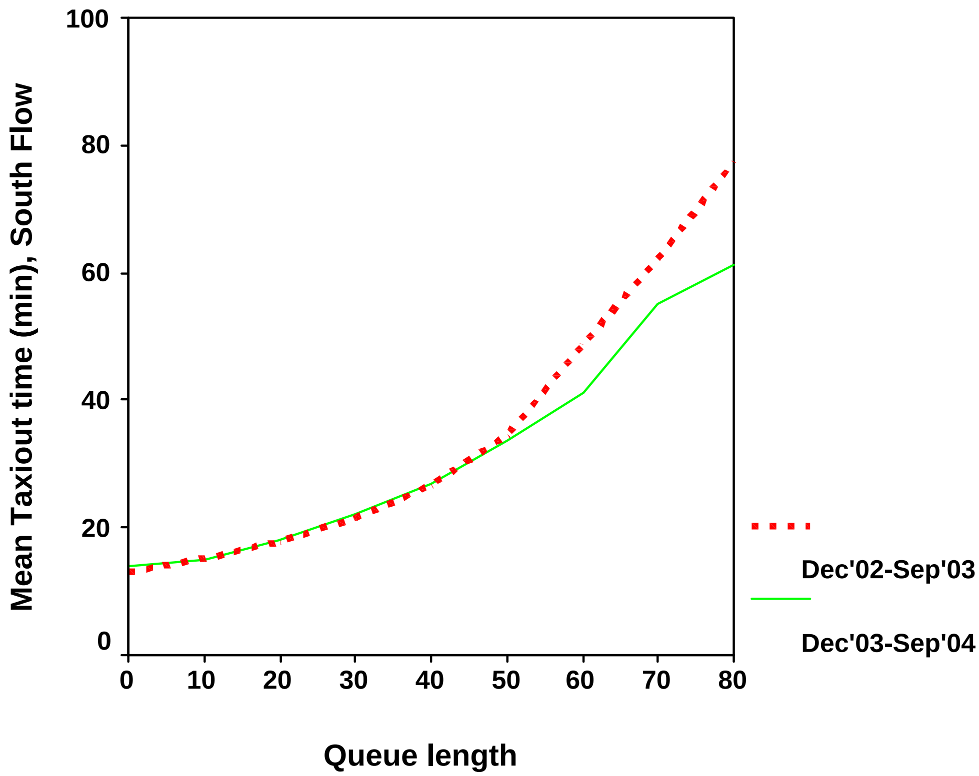


Figure 5-6. Taxi-out vs. queue length for Delta before and after implementation

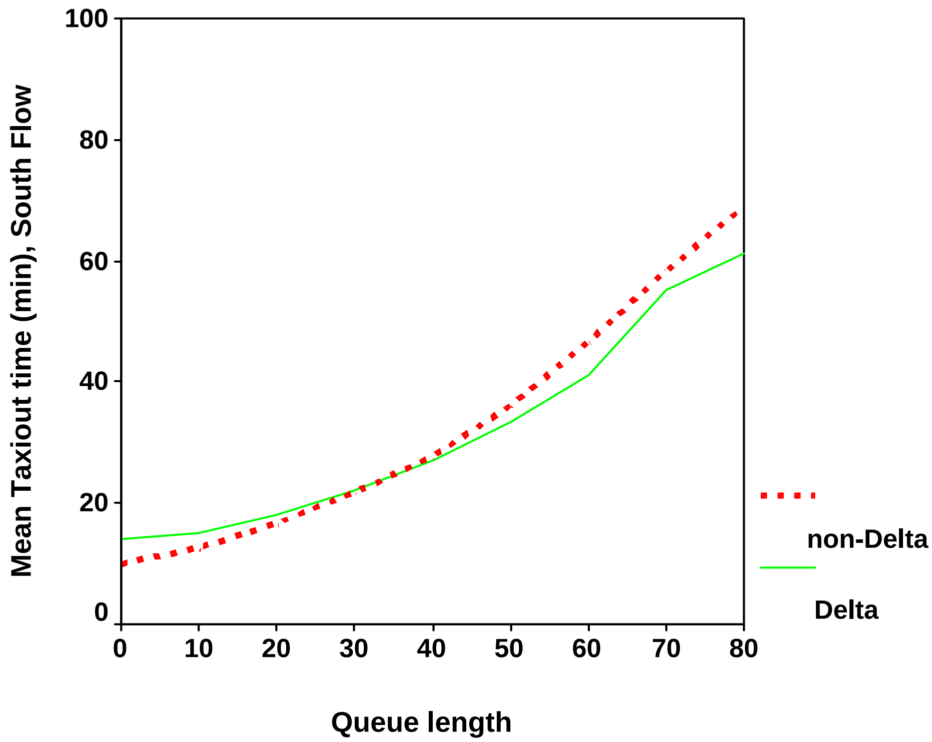


Figure 5-7. Taxi-out vs. queue length for different airlines after implementation

5.3.3 New Future Application Descriptions

The Operations Engineering department of American Airlines began a new effort to find uses for its ASDE-X feed in late summer 2004. They described the following two applications as near-term activities.

Surface route communication

After landing at DFW, aircraft are under local FAA ATC Tower management until they are handed off to airline ramp controllers at specified ramp area entry points. Currently, American Airlines arrivals at DFW must contact the ramp tower to receive proper ramp area entry point location and gate assignment. American is trying to incorporate the ASDE-X feed in their ramp tower to proactively choose the most efficient ramp entry point, and transmit this information to the pilots via ACARS message. This application should reduce radio chatter between airline ramp controllers and pilots, and help to optimize flows on the surface.

Priority Queuing

American Airlines is the dominant carrier at DFW. During many busy times, most or all of the aircraft waiting in the first-come first-serve departure queues are within the American Airlines fleet. During these times, it would be economically beneficial to realign or insert flights with respect to priority or current delay. Since this insertion or reshuffling of aircraft is not in the airline ramp control area, ramp controllers must ask permission to make such maneuvers from the FAA Tower. American believes the ASDE-X display will allow airline controllers the opportunity to detect when insertion of priority flights is reasonable. The display should also provide a common situational awareness between the airline and the FAA ramp tower that should foster cooperative queue management.

6.0 MEM

6.1 System Description and History

SF-21 assisted Federal Express (FedEx) and Northwest Airlines (NWA) in obtaining data for surface surveillance systems for use by ramp controllers and others within these airlines to whom this information is useful. The input for this system currently comes from prototype ASDE-X multilateration. Both FedEx and NWA have tested a variety of commercially available surface management tools to display and process the current data and are actively trying to determine the value of this new information. The multilateration data is also being used as the primary input for the Surface Management System (SMS). SMS is a decision support tool for the ATC tower that will use surface surveillance information to provide accurate arrival/departure demand, predicted pushback times, and runway utilization. SF-21 is transferring responsibility for data sharing to the FAA's ATO Terminal Services Division during FY2004.

6.2 Metrics Activities

FedEx has been using surface surveillance data since April 2003 to enhance surface awareness for controllers in the ramp tower and dispatchers in the systems operations center. ATO Technology Development approached FedEx in November 2003 with the idea of measuring user benefits of shared surface surveillance. Even though SF-21 is transferring responsibility of the surface effort at MEM to ATO Terminal Services, we thought benefit results at this location would be beneficial to our other surface efforts. Also, Terminal Services expressed interest in using our results in their business case for ASDE-X multilateration data sharing.

6.3 Results

Our usual first step at each site is to develop a benefits flow to describe the impacts of the new tool we hope to study. At MEM, Raytheon [13] and NASA [14] had already done detailed benefits descriptions in support of the NASA SMS effort. While the descriptions are not in exactly the same format as ours, they are sufficient to describe the impacts.

As we began to examine benefits at MEM, an opportunity arose to perform a quick study of taxi times. FedEx lost data tags for their surface surveillance system due to a hardware conflict during the FAA installation of the Standard Terminal Automation Replacement System (STARS) on October 27, 2003. The issue was resolved and data tags reappeared on December 17, 2003. In *Performance Metrics Results to Date April 2004* [1], we used this unexpected loss of surveillance to gauge the operational impact of surface data to FedEx. Below, we list the previous results, present new analyses of taxi-out time vs. queue length and departure rate, and repeat results using a different baseline data set.

6.3.1 Summary of Previous Results

As mentioned earlier, FedEx lost data tags for their surface surveillance system for about eight weeks in late 2003. Our previous analysis investigated the operational impact of surface surveillance by examining taxi times for FedEx aircraft at MEM before, during, and after the loss of data.

We found that when the airport is in a North Flow operation (61% of the time), the average taxi-out time is 1.3 minutes less with surveillance during VA conditions and 4.3 minutes less with surveillance during IA conditions. For the same case, the percentage of taxi-out times that are greater than 40 minutes decreases by at least half. We found no significant change in the taxi-out time during South Flow.

6.3.2 New Queue Length and Departure Rate Analyses

Another way to examine surface efficiency is in relation to surface queue length. A recent study [12] found the main factor determining taxi-out time was queue length. We do not have enough information to determine specific runway queue lengths over the time spans involved. However, if we define the queue for an aircraft to be the number of takeoffs between an aircraft's pushback and takeoff, we can have a general measure of airport surface demand that should relate to runway queues.

Comparing taxi-out time to queue length should allow us to examine surface performance in more detail. The queue length accounts for demand better than the mean data and also incorporates weather. We no longer need to remove the large demand holiday period from the data set. However, we still divide the data into different sets by airport configuration to account for difference in terminal location. The output is a curve showing mean taxi-out times for each queue length.

We use ARINC Communications and Address Reporting System (ACARS) OOOI (Out Off On In) data and runway configuration data recorded on the Airport System Performance Metrics (ASPM) database. Approximately 60% of FedEx flights record ACARS data. FedEx provided taxi times for their non-ACARS Boeing 727 fleet over the same time period. Together, this data represents over 90% of the fleet.

Figure 6-1 shows the mean taxi-out time versus queue length during North Flow for the outage period (10/26/2003 - 12/17/2003) and for the surveillance period (the 8-week periods before and after the outage, 9/8/2003-10/25/2003 and 12/18/2003-2/11/2004). All the points on the surveillance curve lie beneath the outage curve. The difference between the curves ranges from a minimum of ten seconds at zero queue, to a maximum near three and a third minutes at a queue length of thirty-five (as indicated in Figure 6-1). This analysis implies that FedEx flights performed better during times with surveillance, and supports the results found from the taxi-out means analysis.

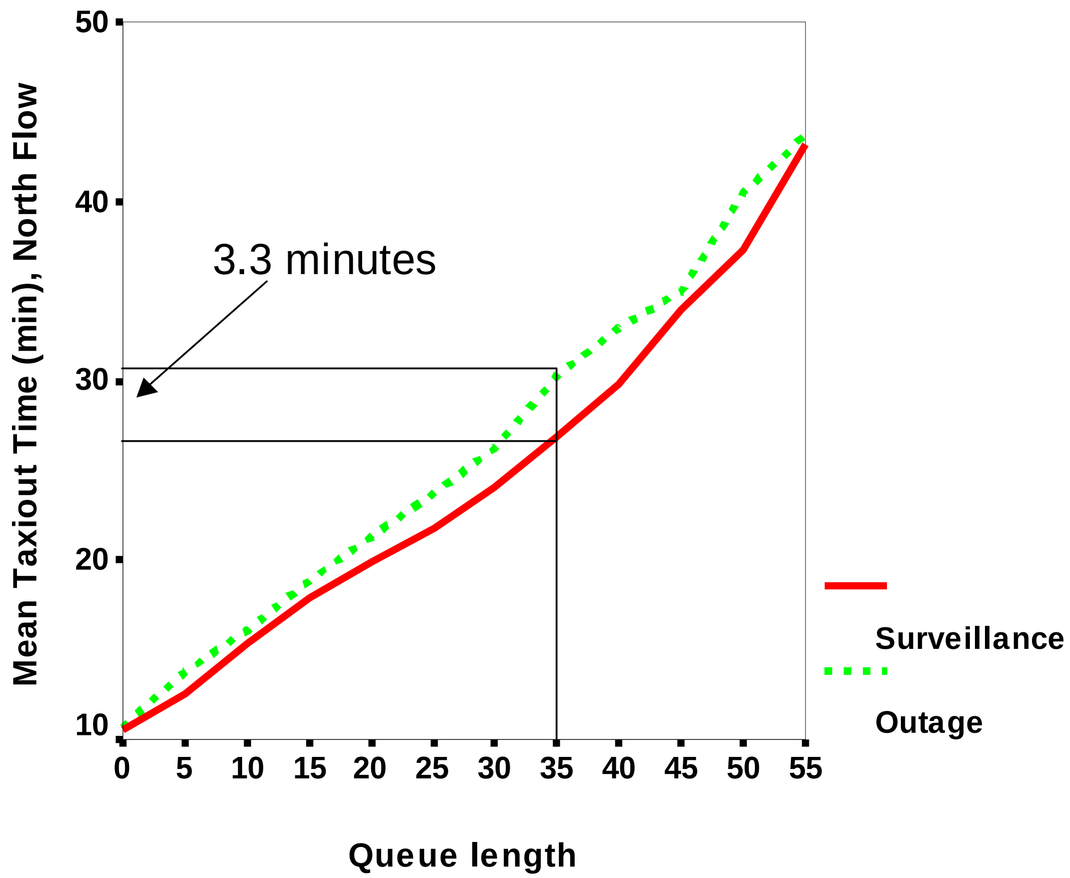


Figure 6-1. Taxi-out time vs. queue length, MEM North Flow

Our definition of queue length also allows examination of airport departure rates. Examining Figure 6-1, we can say that during the surveillance periods it took approximately 28 minutes to depart 35 aircraft, while during the outage it took 31 minutes to depart the same number of aircraft. This corresponds to a decrease in the hourly departure rate from 75 aircraft/hour to 68 aircraft/hour during the outage.

FedEx suggests that increased departure rates during surveillance may be caused by their increased efficiency in runway loading. They believe they affect departure capacity by providing a more consistent number of aircraft to the FAA Tower controllers, and by ordering the aircraft for maximum departure throughput. For example, with the surface surveillance system, FedEx tries to order aircraft so that successive departures have diverging departure routes. This effectively increases runway throughput because it removes potential departure route spacing constraints.

Using the taxi time and queue length values for each flight, we can examine the average departure rates for the different data sets. Figure 6-2 displays the mean hourly departure rate versus queue length during North Flow, for the surveillance period and the outage period. For each value of surface demand (queue length), the average departure rate in the surveillance period is higher. At high demands, both the surveillance and outage curves flatten to approximately 80 aircraft/hour. The departure rate plateau for the surveillance period is greater than that for the outage data by a few aircraft an hour. The departure rate over all the FedEx aircraft is, on average, 2.8 aircraft/hour greater in the surveillance period. The difference in departure rates is significant to the 95 percent level.

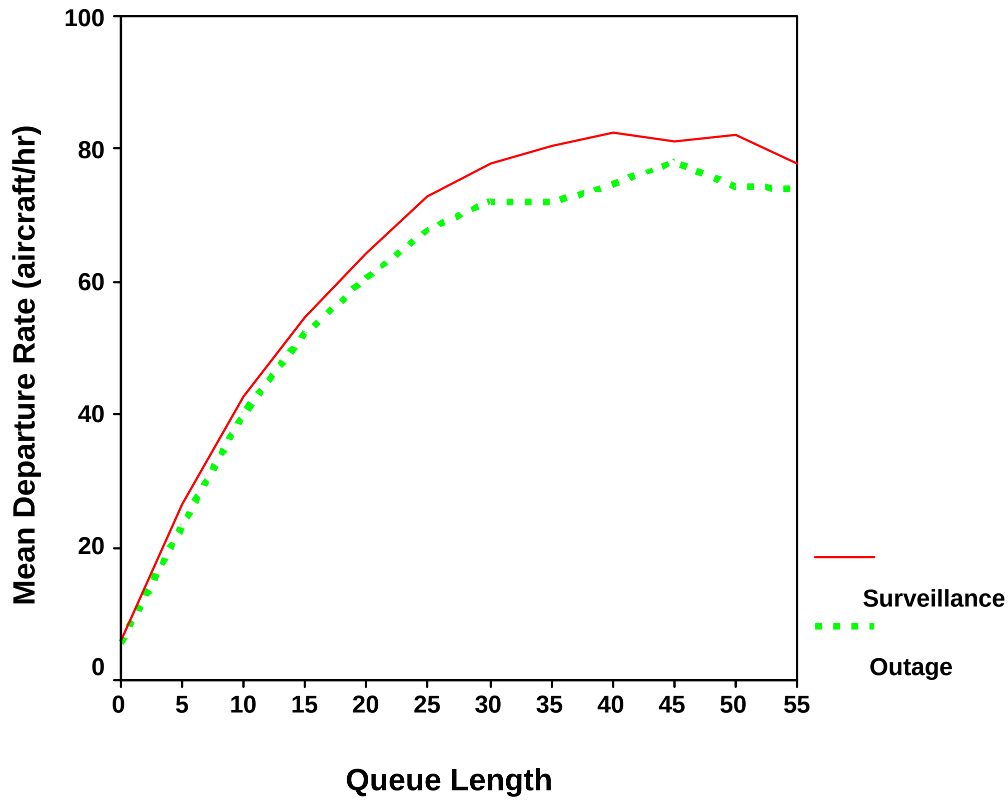


Figure 6-2. Departure rate vs. queue length, MEM North Flow 1

6.3.3 New Taxi-out and Departure Rate Analyses Using Different Baseline Data

As a further confirmation of the surface surveillance benefit at MEM, we decided to compare data after implementation to that before implementation (as opposed to during the outage). Since FedEx reports that they began to use surface surveillance operationally in late March 2003, we chose a baseline period of April 1, 2002 to March 31, 2003, and the post-implementation period as April 1, 2003 through March 31, 2004. We removed November and December flights from both data sets to account for the outage in the post-implementation period.

We repeat the analysis documented in *Performance Metrics Results to Date April 2004* [1] with this new baseline data. However, we did not have access to actual taxi-out times for non-ACARS flights in the new baseline period, so we only use taxi times from ACARS flights in the analysis. Approximately 60 percent of FedEx flights record ACARS data. ACARS data, runway configuration data, and weather data were gathered from the ASPM database.

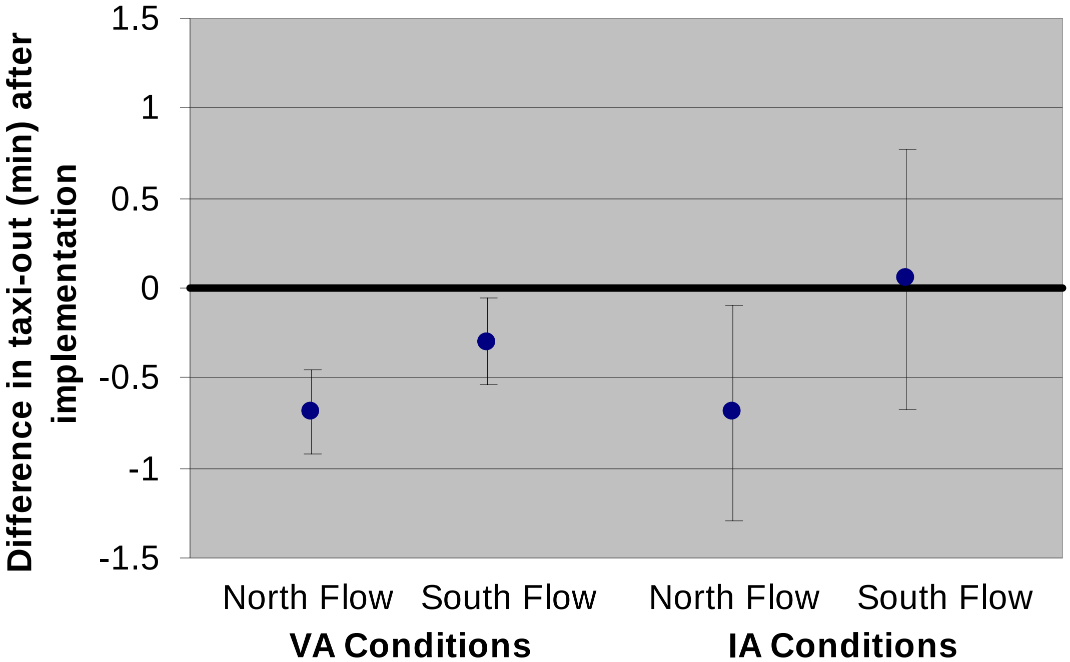


Figure 6-3. Difference in taxi-out time after implementation, MEM

Figure 6-3 displays the difference in mean taxi-out time after implementation of surface surveillance (as compared to baseline period). A negative mean value indicates a reduction in taxi time. The graph shows separate measures for airport weather conditions and runway configurations. The error bars represent the 95 percent confidence interval around the difference in the means as determined by an independent samples T-test. If the confidence interval does not include zero, the difference in the means is significant to the 95 percent level.

Most of the results show decreases in the average taxi time after implementation of surface surveillance in the FedEx ramp tower. For North Flow, the mean taxi time decreased by about 0.7 minutes in both VA and IA conditions. For South Flow, the taxi-out time decreased by approximately 0.3 minutes in VA conditions, and there was an insignificant change in IA conditions.

While the magnitude of the taxi time decreases are less than that found using the outage data, the results generally confirm the supposition that surface efficiency improved after surface surveillance implementation. We believe the magnitude of the outage results to be more accurate because they contain a larger percentage of the traffic (90 percent to 60 percent), and provide less time over which other changes may have affected the surface flow.

We also repeated the queuing and departure rate analysis performed in subsection **6.3.2** using this new baseline data. Figure 6-4 displays the mean hourly departure rate versus queue length during North Flow, for the baseline period and the post-implementation period. For each value of surface demand (queue length) above fifteen, the average departure rate in the surveillance period is higher. Much like Figure 6-2, both the surveillance and outage curves flatten to approximately 80 aircraft/hour, for high demands. The departure rate plateau for the post-implementation period is greater than that for the baseline period by a few aircraft an hour. The departure rate over all the FedEx aircraft is, on average, 3.0 aircraft/hour greater in the post-implementation period. The difference in departure rates is significant to the 95 percent level.

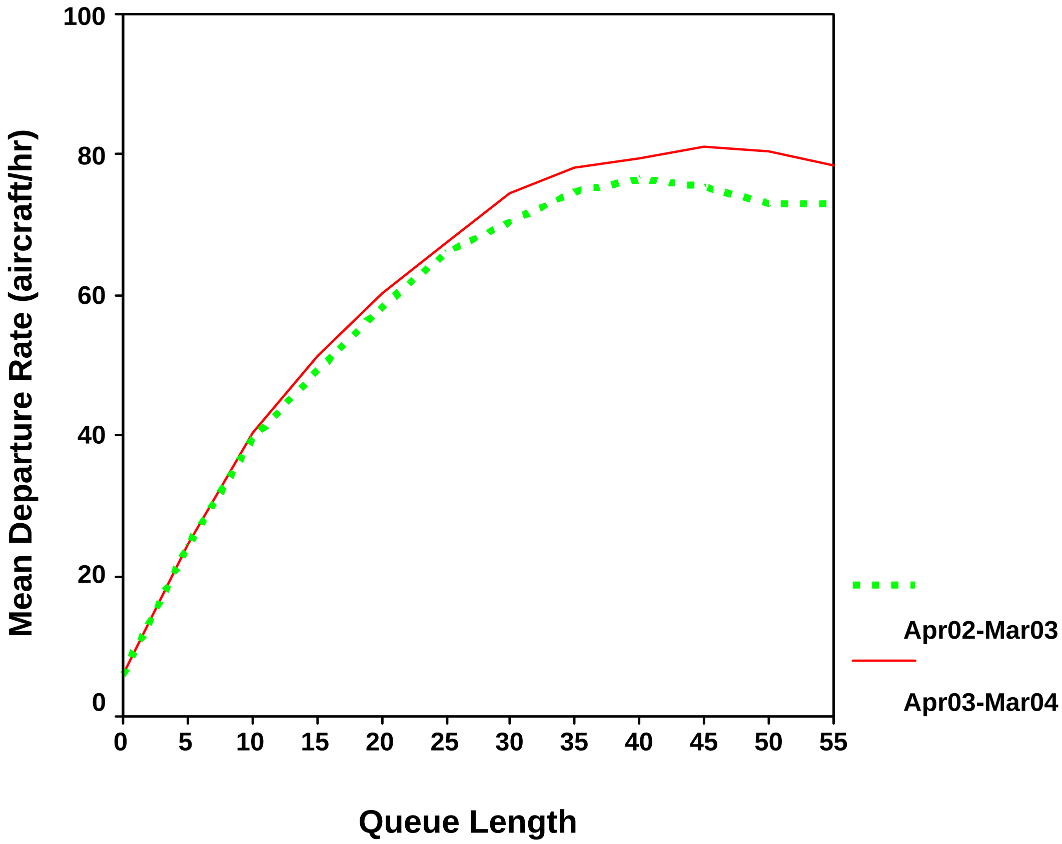


Figure 6-4. Departure rate vs. queue length , MEM North Flow 2

While the mean taxi-out time results using these alternative data sets are different from those using the surveillance outage data, the departure rate results are similar. We believe the departure rate results represent an effective departure capacity increase caused by demand management using shared surface surveillance. This change in departure capacity should be useful for future benefits estimation.

7.0 DTW

7.1 System Description and History

The Airport Target Identification System (ATIDS) is a prototype multilateration system that provides accurate position information of transponder-equipped aircraft operating on the airport surface. A government/industry partnership between the FAA, NASA, Sensis Corporation, and the DTW airport authority installed ATIDS as a research and development project in 1999.

The DTW ATIDS consists of nine remote unit sensors providing surface surveillance coverage. In February 2002, the FAA Safe Flight 21 and Surface Technology Assessment Team (formerly AND-500) installed communications and computer equipment, including three displays within the Northwest Airlines (NWA) ramp tower and displays at the NWA System Operations Center (SOC) in Minneapolis, MN. The purpose of this effort was to probe the benefits of distributing real-time, filtered surveillance data to an airport user. The system provides NWA with aircraft position and flight call sign information. The FAA also prepared a data sharing Memorandum of Agreement with NWA that formally launched the demonstration. During the subsequent one-year period, anecdotal evidence indicated that the sharing of surface surveillance data had a positive impact on efficiency and safety. To further explore these benefits, the FAA established a metrics working group in February 2003.

7.2 Metrics Activities

The working group collected metrics data and other pertinent information to evaluate efficiency and safety. The group included members from the FAA, NWA, NASA, NATCA, DTW ATC, the Volpe National Transportation Systems Center, and Sensis Inc.

In April 2003, at a meeting facilitated by Volpe, the group discussed the current operational impact of ATIDS. Members explained the direct impact of each capability and discussed the benefits that arise from these impacts. Subsequently, we developed a “benefits flow” (Figure 7-1) as described in section **1.3**.

7.3 Results

In *Performance Metrics Results to Date October 2003* [2], we presented the benefits flow and attempted to quantify the impacts where possible. Below, we first summarize the previous results from [2] and then add a new description of how ATIDS helped NWA permanently transform deicing operations. The new description includes a list of long-term changes.

7.3.1 Summary of Previous Results

The summaries below are organized by the benefits flow outcomes seen in Figure 7-1.

• More efficient movement in the ramp area – NWA ramp controllers are responsible for movement in a large area at DTW. They use ATIDS as their primary display in the ramp tower. NWA estimates that these activities currently save 2464 hours of taxi time per year.

• More efficient handling during irregular operations – Irregular operations include times of severe snow and ice, fog, and heavy crosswinds when operations are severely hampered. NWA recently changed its deice operations due to analyses based on post-event ATIDS data. We presented an estimation of the effectiveness of this systematic change in a later benefit. Above and beyond the systematic changes, the NWA SOC documented a real-time use of the ATIDS display that prevented 20-24 cancellations during one particularly bad deicing event in April 2003. The ramp control estimates that ATIDS saves approximately 32 hours of taxi time a year during heavy fog.

• Less likelihood of ramp incidents – While the occurrence of ramp incidents at DTW is quite small, we described how the ATIDS display helps NWA ramp control insure safe operations.

• More efficient maintenance and emergency response (ramp) – NWA ramp control uses ATIDS to help locate and expedite maintenance or emergency flights during low visibility. We presented an example where they used ATIDS to avoid a 5-minute delay on a medical emergency.

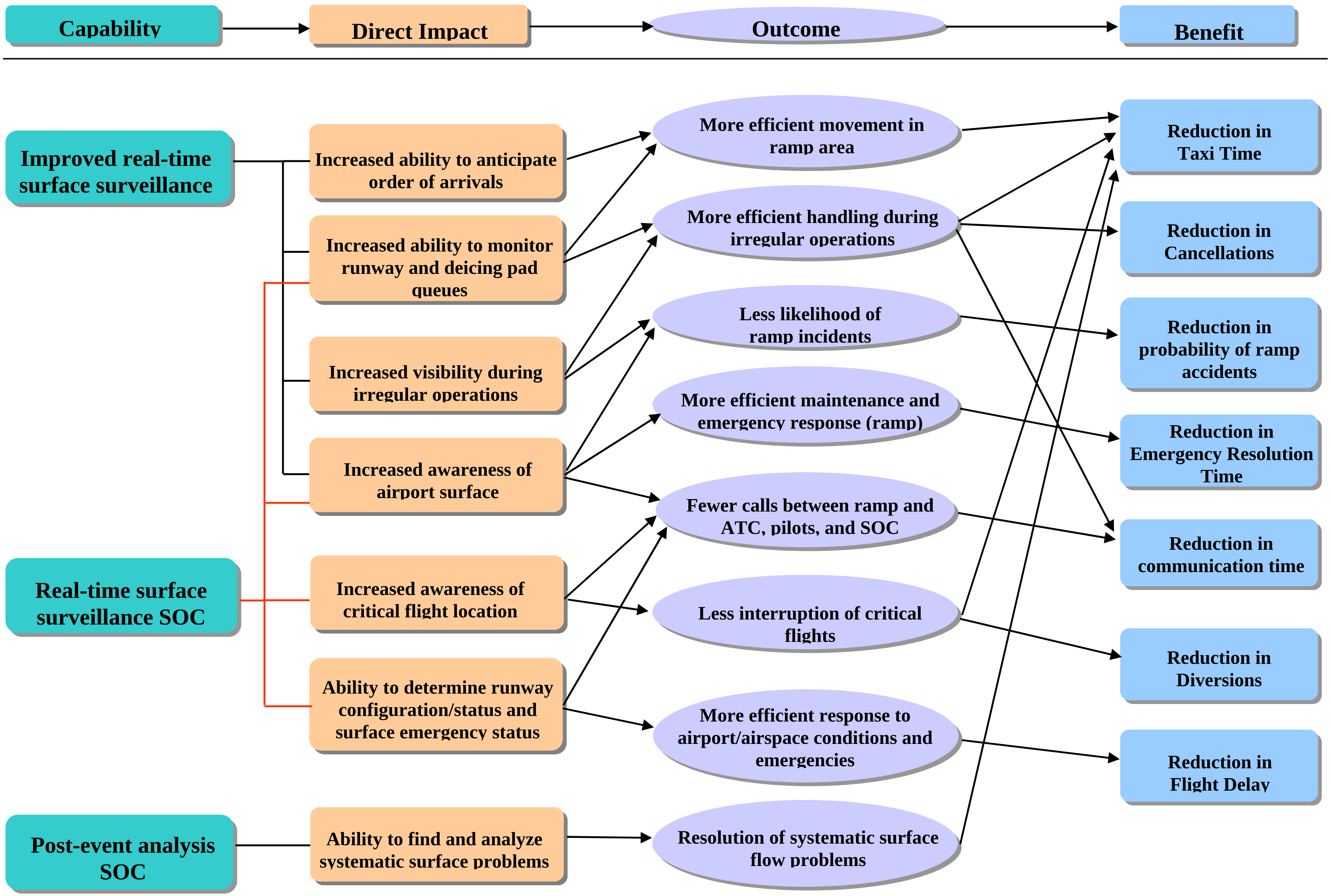
• Fewer calls between ramp, SOC, pilots, and Air Traffic Control (ATC) – Because the ATIDS display provides a means of increased situational awareness, the NWA SOC has been able to reduce calls to the DTW ATC regarding flight location by 75%. Added surveillance on the surface allows NWA ramp control to decrease the number of calls to pilots by 27%.

• Less interruption of critical flights – The NWA SOC uses the tool to gather information on flights that are running close to a curfew or duty limit and propose solutions to ATC. We included some examples of this activity.

• More efficient response to airport/airspace conditions and emergencies – NWA dispatchers at the SOC use ATIDS on a daily basis to reroute flights being held on the ground due to congested en route traffic. We used examples to estimate a yearly savings of 89 hours of block time. The NWA SOC also uses the tool to obtain up-to-date information on potential emergencies at DTW. We included examples of this activity.

• Resolution of systematic surface flow problems – One of the most beneficial recent changes at DTW occurred because of post-event analyses of ATIDS data during a deicing event. We presented an example of how NWA completely changed their deicing procedures because of evidence gathered using ATIDS. The NWA SOC estimated that 432-720 hours of flight delay a year will be saved through ATIDS monitoring after changes made in the procedures. We also described how NWA is using ATIDS to examine other procedural issues.

Figure 7-1. DTW Data Sharing on Surface Benefits Flow



7.3.2 New Description of Deicing Changes

It is hard to overstate the disruptive effect of severe winter weather on airport surface operations. Aircraft must wait in deicing queues before becoming eligible to join runway queues. Snow removal hampers runway use. If aircraft wait too long to leave the ground after being deiced (missing holdover times), they must repeat deicing procedures. Air traffic and airline ramp controllers must contend with limited visibility while directing traffic in the movement and ramp areas. Airline operation center management must weigh the impact of canceling flights or allowing flights to be delayed. In this decision, they must consider balancing runway and deicing throughput capacity, passenger considerations, pilot and flight attendant legality issues, and aircraft routings. A recent study on the causes of delay at Newark International Airport found that winter weather increased average delay by 10 percent and doubled the average number of cancellations.[1]

One of the major benefits of surface surveillance agreed upon by both the ramp tower and the SOC involved periods of deicing.

Figure 7-2 displays a diagram of DTW with the runways and buildings shaded black and the taxiways and ramp areas shaded gray. Deice pad areas are designated with triangles.

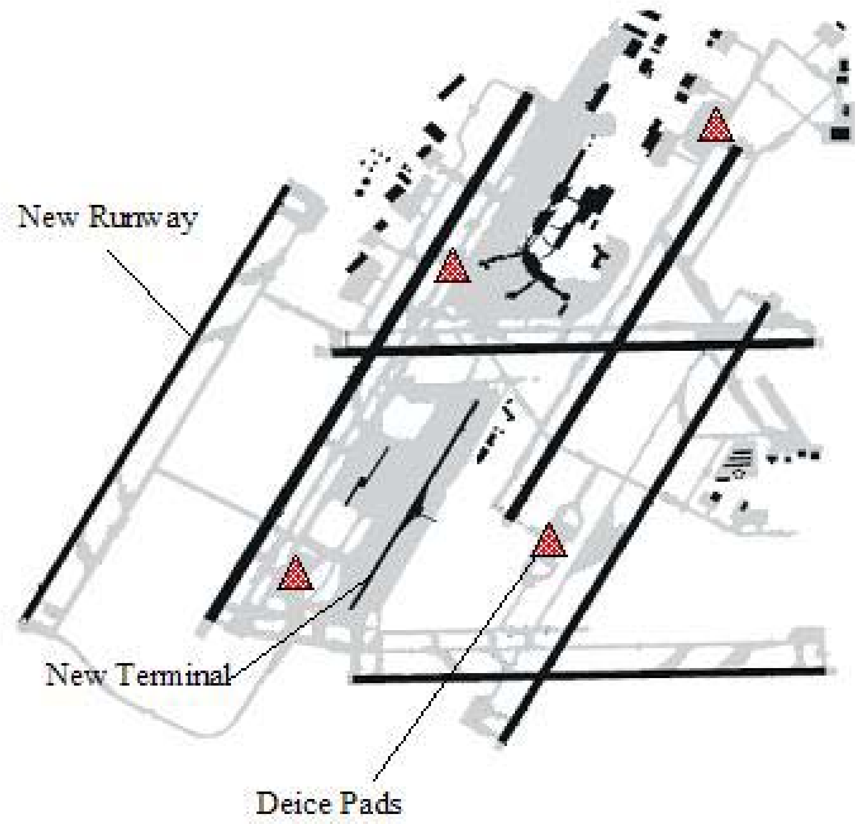


Figure 7-2. Layout of DTW with triangles designating deice pads

On January 2, 2003 a moderate snowstorm hit DTW. This was the first severe weather event where ATIDS was fully operating in real-time at the NWA SOC. During the storm, analysts and managers examined the ATIDS display and visually noticed some of the inefficiencies in the deicing operation. Specifically, they noticed that during certain times one of two primary operating pads had a large queue, while the other one was virtually empty. Each of the pads can hold up to six aircraft simultaneously. The NWA SOC identified instances when at least one position within the pad was empty while aircraft were queued awaiting deicing. They also watched specific flights to examine waiting and deice times. An international departure, a B747 that contained many passengers and connections at Narita International Airport in Tokyo, was not expedited to the deicing pad and instead waited 40 minutes before arriving at the deicing pad.

The real-time awareness of deicing problems prompted a meeting the following day with senior operations management. At this meeting, SOC analysts used the archived track information to replay traffic and presented analysis of the deicing throughput and deicing pad distribution. They also estimated excess taxi-out times compared to what would be expected for a snow event of this magnitude.

Before ATIDS, detection of surface problems relied on debriefing from DTW employees. While information from local eyes is still crucial for understanding a situation, the archived data assists in quantifying the magnitude of a problem. Note we do not claim that ATIDS can analyze surface flow problems; it only provides a better source of data. Any analysis is therefore due to analysts who know how to take advantage of better data.

Because of the ATIDS-enabled analysis and subsequent discussions NWA made several long-term changes to deicing procedures. These changes included:

- Re-defining responsibilities for deice pad loading between ATC Tower and NWA Ramp tower in order to balance the loading
- Using the display to assist with communication between NWA ramp tower and FAA ATC tower
- Moving the NWA deicing coordinator from a truck on the surface to the ramp tower, so that he could view traffic on the display
- Adding deicing refill trucks to deice pads
- Continual monitoring of the display for deice rate and deice pad capacity and distribution
- Deicing of wide-body aircraft (B747, DC10’s) at the gate instead of at the deice pads
- Moving commuter jet deicing to a separate deicing pad
- Developing a plan to hold aircraft at the gate if the deice queue becomes too long

- Re-emphasizing the need for every flight to activate their transponder while on the ground so that they will be visible on the display.

NWA believes that such changes would have been much more difficult to implement without detection of the underlying problems and analysis of the data made possible by ATIDS. Most of the changes listed represent a one-time fix of the system. However, part of the change in operations depends on real-time monitoring of traffic and deicing flows with the ATIDS display. The NWA SOC determined that they handle approximately 16 deicing events at DTW during a season. Using an estimate of 89 hours of delay calculated from the January 2, 2003 incident, NWA estimates a total yearly delay of 1424 hours. Further analysis suggested that tactical changes made using real-time monitoring of flows during deicing events could reduce delay by 432-720 hours a year, a reduction of 30 percent to 50 percent of the total.

During the winter of 2003-2004, NWA routinely examined airport operations after snow or deicing events recorded from the surface surveillance information. They examine taxi times, deice times, and deicing pad usage, taking departure bank, departure runway, and aircraft type into account. Figure 7-3 displays an example of a deicing pad loading graph used to examine load balancing. Continued benefits from this tool convinced NWA to pursue a similar surface surveillance system for their Minneapolis hub.

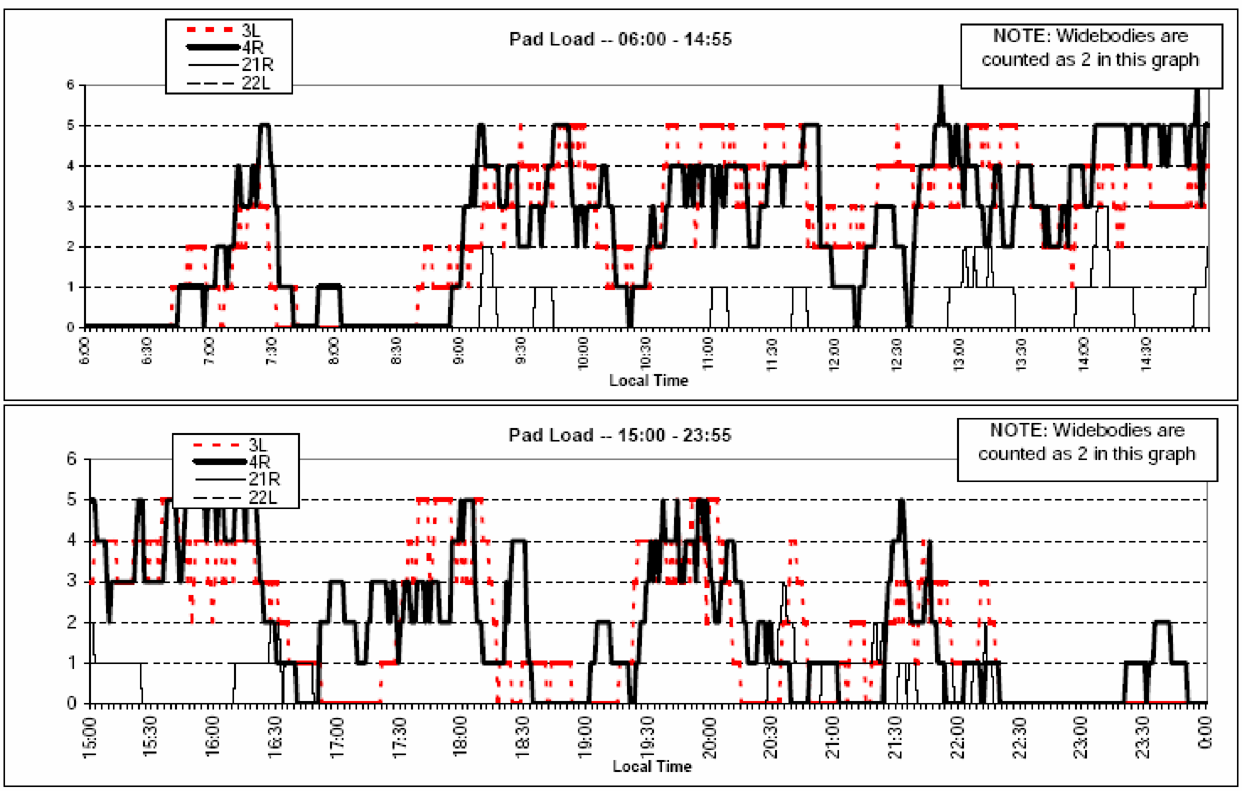


Figure 7-3. Pad loading example from March 16, 2004

8.0 VGT

8.1 System Description and History

The Surface Technology Assessment Product Team of ATO Technology Development is testing the effectiveness of enhanced additional Runway Guard Lighting (RGL) as a runway incursion prevention tool to be used uniformly on the airport surface during all weather conditions. These lights assist pilots in identifying the runway hold position usually identified by surface markings or runway hold signs. Some airports already have RGL, but use it only at high incursion intersections, known as "hot spots," and in accordance with Advisory Circular (AC) 120-57, the Surface Movement Guidance and Control System (SMGCS). This circular requires a low visibility taxi plan for any airport that has takeoff or landing operations during less than 1,200 feet runway visual range (RVR) visibility conditions. Current FAA ACs do not provide guidance for RGL usage during non-SMGCS operations. Consequently, use of RGL is inconsistent from airport to airport. Surface Technology Assessment hopes to standardize the use of RGL for non-SMGCS operations.

As a test of total airport RGL, Surface Technology Assessment has installed RGL throughout the entirety of North Las Vegas Airport (VGT), in North Las Vegas, Nevada. A study performed by the William J. Hughes Technical Center [15] in January 2004 gathered baseline data for runway identification distances using current surface markings and signs. RGL became operational at all VGT intersections in October 2004. A follow-on study to determine the new runway identification distances is currently in progress.

8.2 Metrics Activities

The most obvious operational benefit of RGL would be a reduction in runway incursions caused by pilot deviations. Over fifty-five percent of reported runway incursions were caused by pilot deviations. RGL should increase pilot situational awareness and prevent incursions. We will examine the runway incursion rate periodically to probe for changes in the rate due to RGL. The Surface Technology Assessment Team is also trying to provide evidence for increased situational awareness through the technical distance tests mentioned above and pilot surveys.

In addition, the Surface Technology Assessment Team has been gathering data to examine runway incursions before and after implementation of "hot spot" RGL at other airports. The task is complicated by inconsistent use of RGL across the different airports. More specifically, different airports use RGL for different weather conditions and RGL placement is currently limited to a small number of intersections.

As operations continue, we will report on further activities at VGT and perform analyses when feasible.

9.0 REFERENCES

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10.0ACRONYMS

ACARS	Addressing, Communications, and Reporting System
ADIZ	Air Defense Identification Zone
ADS-B	Automatic Dependent Surveillance – Broadcast
AND-500	Past FAA routing symbol for office now within ATO Technology Development
ATIDS	Airport Target Identification System
AOC	Airline Operations Center
AOPA	Aircraft Owners and Pilots Association
AOZ-40	FAA Free Flight Program Office
ARINC	Aeronautical Radio, Inc.
ARTCC	Air Route Traffic Control Center
ARTS	Automated Radar Tracking System
ASDE-X	Airport Surface Detection Equipment Model X
ASPM	Aviation System Performance Metrics
ASR	Airport Surveillance Radar
ATA	Air Transport Association
ATC	Air Traffic Control
ATO	Air Traffic Organization
BAW	British Airways
B-757	Boeing 757
B-767	Boeing 767
CAASD	Center for Advanced Aviation System Development
CBA	Cost Benefit Analysis
CDTI	Cockpit Display of Traffic Information
CEFR	CDTI-Enhanced Flight Rules
CFIT	Controlled Flight into Terrain
CNAC	Center for Naval Analysis Corporation
CRABS	Comprehensive Real-time Analysis of Broadcast Systems
CTAS	Center TRACON Automation System
DFW	Dallas-Fort Worth Airport
DLH	Lufthansa
DPS	Department of Public Safety
DTW	Detroit Wayne County Airport
EFC	Expected Further Clearance
EOC	Emergency Operations Center
ERAU	Embry-Riddle Aeronautical University
ETA	Estimated Time of Arrival
ETMS	Enhanced Traffic Management System
EVA	Enhanced Visual Approach
FAA	Federal Aviation Administration

FedEx	Federal Express, Inc.
FFP	Free Flight Program
FIS-B	Flight Information Service-Broadcast
GEMS	Global Engineering Management Services, Inc.
GMT	Greenwich Mean Time
GOM	Gulf of Mexico
GPS	Global Positioning System
HAME	Host Aircraft Management Executive
HSAC	Helicopter Safety Advisory Conference
IA	Instrument Approaches
IBE	Iberia Airlines
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
JHUAPL	Johns Hopkins University Applied Physics Laboratory
KE	Korean Airlines
MAP	Monitor Alert Parameter
MEM	Memphis International Airport
MFD	Multi-functional Display
MLAT	Multilateration
MOU	Memorandum of Understanding
MVA	Marginal Visual Approaches
MVMC	Marginal Visual Meteorological Conditions
NAS	National Airspace System
NASDAC	National Aviation Safety Data Analysis Center
NASA	National Aeronautics and Space Administration
NATCA	National Air Traffic Control Association
NCDC	National Climatic Data Center
NMAC	Near Mid-Air Collision
nmi	Nautical mile(s)
NORAD	North American Aerospace Defense Command
NTX	NASA North Texas Station
NWA	Northwest Airlines
OEP	Operational Evolution Plan
OOOI	Out Off On In
PD	Pilot Deviation
RAA	Regional Airport Authority
RCC	Ramp Control Center
RIRP	Runway Incursion Reduction Program
RTCA	RTCA, Inc.
RWSL	Runway Status Lights
SDF	Louisville International Airport – Standiford Field

SF-21	Safe Flight 21
SMS	Surface Management System
SOC	System Operations Center
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
SWR	Swiss International
TCAS	Traffic Alert and Collision Avoidance System
TESIS	Test and Evaluation Surveillance Information System
TIS-B	Traffic Information Service-Broadcast
TRACON	Terminal Radar Approach Control Facility
UPS	United Parcel Service
VA	Visual Approaches
VFR	Visual Flight Rules
VIR	Virgin Airlines
VMC	Visual Meteorological Conditions
ZHU	Houston ARTCC